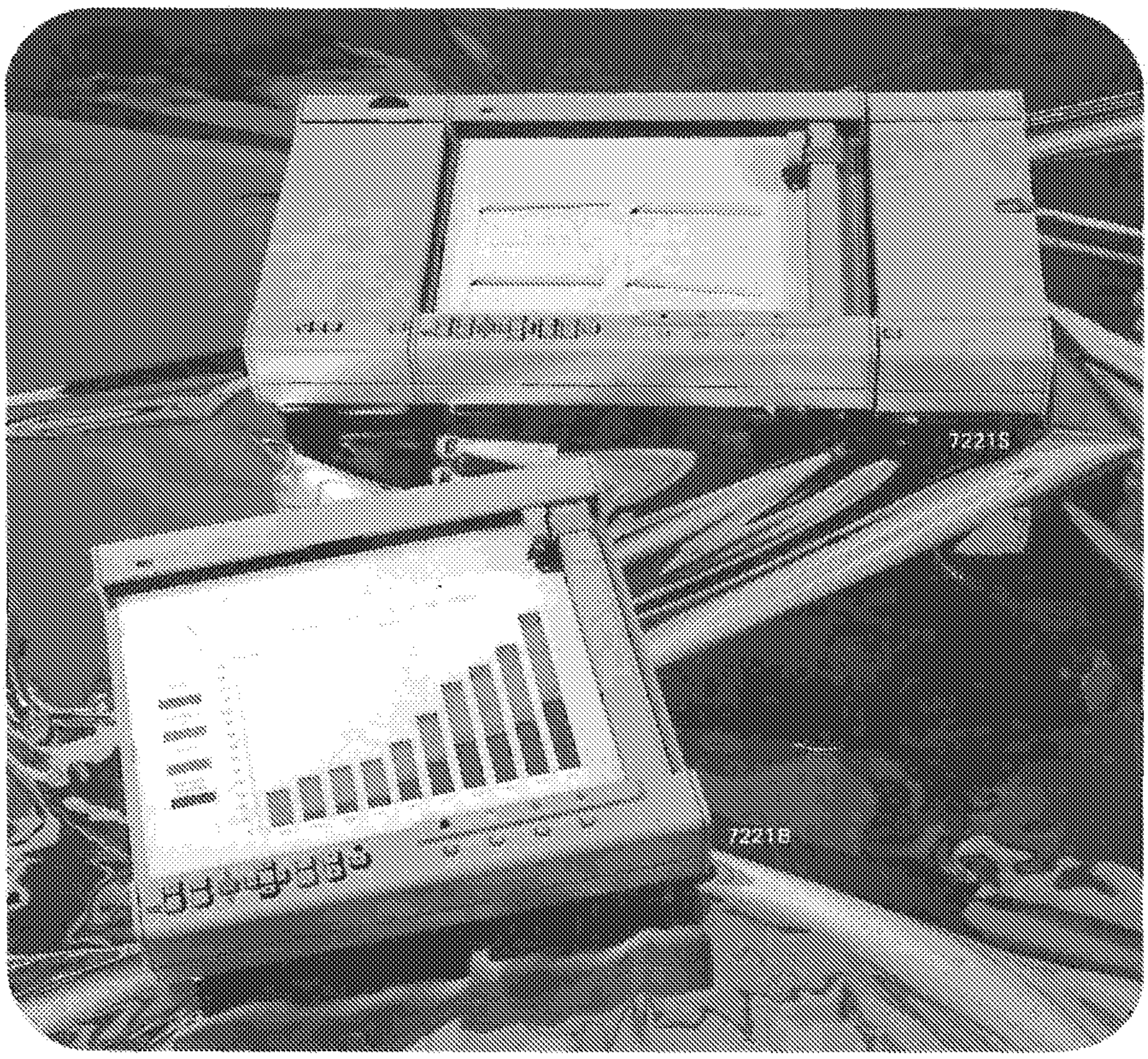
·lett-Packard 7221B and 7221S Graphics Plotter Operating and Programming Manual



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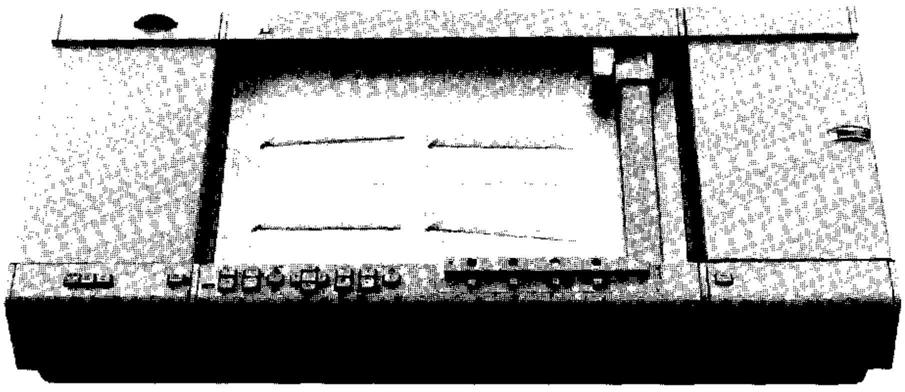
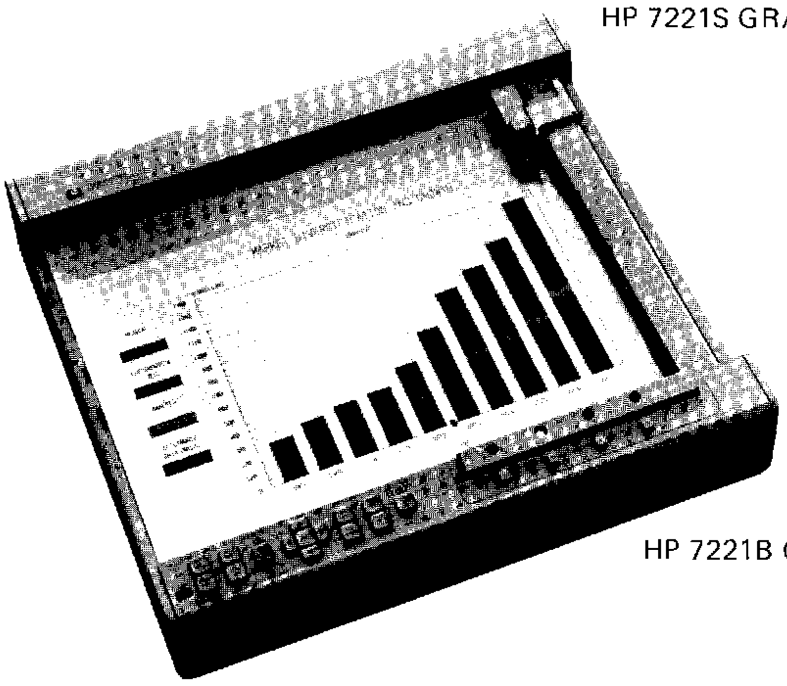


HP 7221S GRAPHICS PLOTTER



HP 7221B GRAPHICS PLOTTER

Hewlett-Packard
16399 W. Bernardo Drive, San Diego, California 92127
(For World-wide Sales and Services Offices see appendix)

August 1979

Manual Summary

Operating Instructions

Chapter 1. Owners Information

Contains inspection procedures, specifications, accessories, power requirements, operator maintenance procedures and shipment information.

Chapter 2. Preparation For Use

Contains control descriptions, pen and paper loading instructions, procedures for running the confidence test, plot initialization instructions, installation/operation of the digitizing sight, operation of front-panel controls, and installation/operating instructions for using the plotter with host computers and terminals.

Tutorial Information For Programming

Chapter 3. General Programing Information

Provides discussions of operating modes, plotter capabilities, functional operation, and the philosophy of binary formatting.

Chapter 4. Basic Programming Functions

Describes turning the plotter on and off, selecting pens, setting graphic limits and grid size, performing moves and draws, and performing incremental moves and draws.

Chapter 5. Labeling

Defines the label string, presents the label group instructions, discusses invoking and terminating the label mode, altering character size, spacing and slant, selecting a label font, defines the format effectors, and provides instructions for label character rotation.

Chapter 6. Extended Graphic Instructions

Contains program information for drawing circles and arcs, performing rotations and drawing fixed and variable dash lines.

Manual Summary (Continued)

Chapter 7. Macro Instructions

Defines the macro invoke/terminate instruction, provides examples of defining and invoking macros, erasing macros, and using automatic macros.

Chapter 8. Input/Output Operations

Contains program information for establishing the output mode, defines the output group and the output abort function. Also defines handshake protocol, the input operation, and plotter configurations.

Programming Instructions

Chapter 9. Parameter Encoding

Defines parameter types and lengths, describes the binary format functions and provides a detailed description of each type parameter used in programming the plotter.

Chapter 10. Instruction Set

Defines and describes each Device Control and Graphic Instruction.

Chapter 11. Interfacing The Plotter

Provides information on the plotter data connectors, interface wiring, signal characteristics, control line protocol, transmission errors, and baud rate characteristics.

Appendix A. Label Mode Character Sets (Fonts)

Appendix B. Binary Coding Table

Appendix C. Plotter Status And Error Codes

Appendix D. ASCII Code Table

Appendix E. Device Control And Graphic Instructions

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Plotter Overview

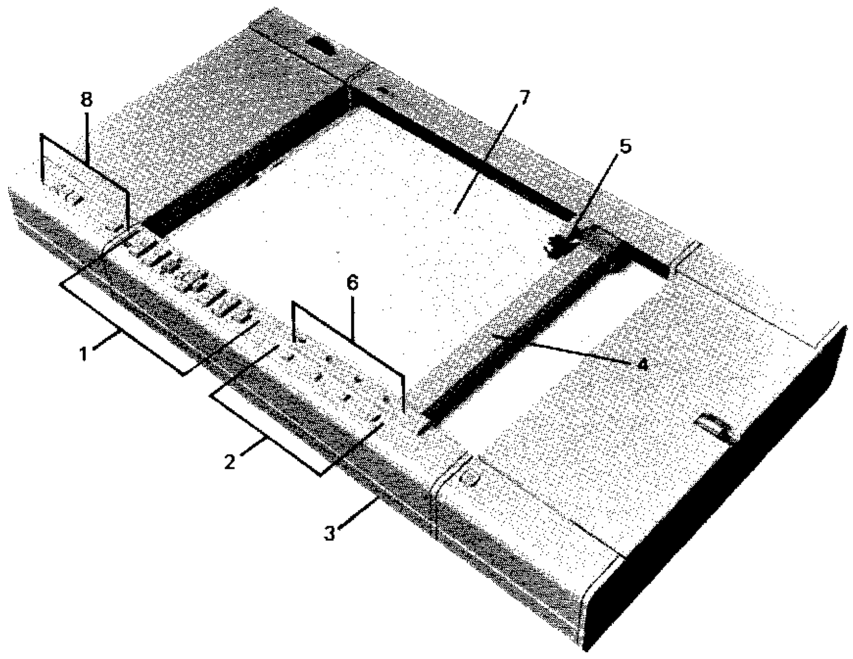


Figure 1-1. Model 7221B and 7221S Graphic Plotters

1. Plotter Function Controls and Indicators	Used for operator control and provides indications of various plotter functions. Refer to Chapter 2 for a detailed discussion of these controls.
2. Pen Select Controls	Permits operator selection of any one of four pens in the pen stable (item 6).
3. LINE Switch (on lower deck)	Controls application of primary power to the plotter.
4. Pen Arm	Provides pen movement in the X-Axis.
5. Pen Holder	Carries plotter pen and provides pen movement in the Y-Axis.
6. Pen Stable	Houses four interchangeable pens. The color of the pen loaded in each stall is visible through an aperture in the top of the panel.
7. Platen	Plotting table with electrostatic sheet paper holddown.
8. Paper Advance Controls	7221S only.

Chapter 1

Owners Information

Introduction

This manual contains operating and programming information for the Model 7221B and 7221S Graphic Plotters.

Both models feature four color plotting, relative and absolute plotting with addressable moves of 0.025 mm (0.001 in.), programmable pen velocity, and multiple internal character sets. In addition, the Model 7221S is enhanced by the paper advance option.

The built-in microprocessor controls over forty programmable instructions utilizing compacted binary language to minimize connect time during communication with a remote computer facility. Interface is RS-232-C/CCITT V.24 asynchronous serial ASCII at one of eight switch selectable baud rates of from 75 to 2400 baud.

The level of information in this manual is organized into three categories: overall familiarization and operation; tutorial programming information; and detailed programming information. Five appendices are also included which contain often used reference material and the complete plotter instruction set.

For further familiarization, it is suggested that the user refers to the complete plotter instruction set foldout in Appendix E while studying the information contained in this manual.

This chapter contains the following information:

- Inspection Procedures
- Plotter Specifications
- Accessories Supplied
- Accessories Available
- Grounding Requirements
- Power Requirements
- Fuse Information
- Line Voltage Selection
- Power Cord Use
- Operator Maintenance
- Shipment Information

Inspection Procedures

The individual parts of your plotter were thoroughly inspected before the unit was shipped to you, and the instrument should be in good operating order. Carefully inspect the plotter and accessories for any physical damage sustained in transit. Notify the nearest HP sales office and file a claim with the carrier if the unit is received in a damaged condition.

Please check to ensure that you have received all of the items that should accompany the plotter. A list of these accessories is contained later in this chapter. If you have any difficulties with the plotter, if it is not operating properly, or if accessories are missing, contact the nearest HP sales and service office; addresses are supplied at the back of this manual.

WARNING

The 7221S is a large, heavy device (65 lb). Do not attempt to unpack it or move it to a different location alone.

To move or unpack the 7221S, grasp the lower support bars at each end and lift the plotter.

Retain the original packing materials and carton. If the plotter must be shipped, this will save having to order new packing materials and a carton from HP.

Plotter Specifications

PLOTTING AREA: 285 x 400 mm (11.22 x 15.75 in.). Platen will accommodate 280 x 432 mm (11 x 17 in.) or ISO A3 sheet paper. In addition, the 7221S will accommodate roll paper perforated at either 11 in. or ISO A3 width.

PLOTTING ACCURACY: ±0.2% of deflection. ±0.2 mm (includes linearity and repeatability).

REPEATABILITY: Single Pen: ±0.10 mm (0.004 in.) from any given point approached from any direction. Pen-to-Pen: ±0.20 mm (0.008 in.) without resetting zero coordinates.

ADDRESSABLE RESOLUTION: Programmable with 0.025 mm (0.001 in.) as the smallest addressable move.

MAXIMUM VELOCITY: 360 mm/s in each axis, 509 mm/s on 45° angle.

PROGRAMMABLE VELOCITY: 36 speeds from 10 mm/s to 360 mm/s in steps of 10 mm/s.

VECTOR LENGTH: Any length within the plotting area.

CHARACTER PLOTTING: Typically 3 char/s for 2.5 mm characters.

CHARACTER SET: 6 resident sets; ANSI Standard ASCII, HP 9872A ASCII, European Set, Scandanavian Set, Spanish and Latin American Set and Graphic Symbol Set.

PAPER HOLDDOWN: Electrostatic for sheet paper. Tension for roll paper.

PAPER ADVANCE OPERATION: 7221S only. Programmable control or local control with front-panel pushbutton.

PAPER CUTTER: 7221S only. Programmable control or local control with front-panel pushbutton.

WRITING MECHANISM: Disposable fiber tip ink pens.

PEN POSITION CONTROLS: Remote control by program. Local control by front-panel pushbuttons. Capable of greater than 20 operations per second. Local control provides rates of 4.2 mm/s (slow) and 93.2 mm/s (fast).

ENVIRONMENTAL LIMITS:

Operating:	Temperature: 0 to 55°C Relative Humidity: 5% to 95%, 40°C and below Altitude: Up to 4600 metres (15,000 feet)
Storage:	Temperature: -40° to +75°C Relative Humidity: 5% to 95%, 40°C and below Altitude: Up to 15,500 metres (50,000 feet)

POWER REQUIREMENTS: 100, 120, 220, 240 Vac; +5 -10%; 48-66 Hz; 180 watts maximum.

SIZE/WEIGHT:	7221B	7221S
Height:	189 mm (7.5 in.)	210 mm (8.3 in.)
Width:	497 mm (19.5 in.)	858 mm (33.8 in.)
Depth:	455 mm (18 in.)	455 mm (18 in.)
Net Weight:	18.2 kg (40 lb)	29.6 kg (65 lb)
Shipping Weight:	25.4 kg (56 lb)	42.5 kg (93.5 lb)

INTERFACE CABLE: RS-232-C/CCITT V.24 male-to-male.

INTERFACE: RS-232-C/CCITT V.24 asynchronous serial ASCII with switch selectable baud rates of 75, 110, 150, 200, 300, 600, 1200 or 2400 baud. Two port, female connectors.

Accessories Supplied

DESCRIPTION	QUANTITY	PART NUMBER
Accessory Kit — includes the following items:	1	09872-60070
Four Color Pen Pack	4 Pkg. of 4	5060-6810
Digitizing Sight	1	09872-60066
Dust Cover: 7221B	1	9222-0564
7221S	1	9222-0681
Male-to-Male Interface Cable (RS-232-C/CCITT V.24)	1	07221-60157
Sheet Paper, Standard Grid, English 11 x 17 in., 10 grids/in., 10 x 15 in. grid area	10 Sheets	9270-1004
Sheet Paper, Standard Grid, Metric 280 x 420 mm, 1 grid/mm, 250 x 380 mm grid area	10 Sheets	9270-1024
Roll Paper, English (7221S only)	1	9280-0493
Paper Tray Assembly (7221S only)	1	17072-60023
Power Cord	1	(As ordered — refer to Fig. 1-4)
Operating and Programming Manual	1	07221-90014

Accessories Available

DESCRIPTION	QUANTITY	PART NUMBER
DISPOSABLE PENS		
Red	5	5060-6784
Blue	5	5060-6785
Green	5	5060-6786
Black	5	5060-6787
Four color pen pack	4 Pkg	5060-6810
11 x 17 SHEET PAPER – ENGLISH		
Blank (10 x 15 in. writing area)	100 Sheets	9280-0180
Standard grid (10 x 15 in. grid area)		
Heavy paper	100 Sheets	9270-1004
Lightweight paper	100 Sheets	9270-1005
Gemkote® paper	100 Sheets	9280-0269
Semilogarithmic (10 x 15 in. grid area)		
Linear x 2 cycle	100 Sheets	9280-0159
Linear x 3 cycle	100 Sheets	9280-0160
3 cycle x linear	100 Sheets	9280-0168
2 cycle x linear	100 Sheets	9280-0169
Logarithmic		
2 cycle x 3 cycle (10 x 15 in. grid area)	100 Sheets	9280-0167
3 cycle x 2 cycle (10 x 15 in. grid area)	100 Sheets	9280-0165
3 cycle x 4 cycle (10 x 13.33 in. grid area)	100 Sheets	9280-0171
8½ x 11 SHEET PAPER – ENGLISH		
Standard grid (7 x 10 in. grid area)		
Heavy paper	100 Sheets	9270-1006
Lightweight paper	100 Sheets	9270-1007

Accessories Available (Continued)

DESCRIPTION	QUANTITY	PART NUMBER
8½ x 11 SHEET PAPER – ENGLISH (Continued)		
Logarithmic (7 x 9.33 in. grid area)		
3 cycle x 4 cycle	100 Sheets/Box 50 Box Min.	9280-0172
Special paper		
Smith chart (7.25 in. diameter)	100 Sheets/Box 50 Box Min.	9280-0137
Smith chart expanded (7.25 in. diameter)	100 Sheets	9280-0147
280 x 420 MM SHEET PAPER – METRIC		
Blank (250 x 380 mm writing area)	100 Sheets	9280-0180
Standard grid (250 x 380 mm grid area)		
Heavy paper	100 Sheets	9270-1024
Lightweight paper	100 Sheets	9270-1042
216 x 280 MM SHEET PAPER – METRIC		
Standard grid (180 x 250 mm grid area)		
Heavy paper	100 Sheets	9270-1023
Lightweight paper	100 Sheets	9270-1027
Gemkote® paper	100 Sheets/Box 50 Box Min.	9280-0272
8½ x 11 PAD PAPER – ENGLISH		
Blank (7 x 10 in. writing area)	50 Sheets	9280-0475
216 x 280 MM PAD PAPER – METRIC		
Blank (180 x 250 mm writing area)	50 Sheets	9280-0476

Accessories Available (Continued)

DESCRIPTION	QUANTITY	PART NUMBER
ROLL PAPER – ENGLISH		
Roll (200 ft)	1 Roll	9280-0494
ROLL PAPER – METRIC		
Roll (61 m)	1 Roll	9280-0493
OVERHEAD TRANSPARENCY KIT – 17055A		
Includes:		
4 pens (blk, red, blu, grn) 0.25 mm tip	1 Pkg	5060-6818
4 pens (blk, red, blu, grn) 0.7 mm tip	1 Pkg	5060-6819
4 pens (blk, orn, brn, vio) 0.25 mm tip	1 Pkg	5060-6834
4 pens (blk, orn, brn, vio) 0.7 mm tip	1 Pkg	5060-6835
Solvent, 29.6 ml (1 fl. oz.)	1 Container	5060-6828
Transparency film	100 Sheets/Pkg (2 Pkgs)	9270-0639
MANUALS		
7221B Service Manual	1	07221-90012
7221S Service Manual Supplement	1	07221-90013
HP-PLOT/21 Software User's Manual	1	07221-90015

Refer to HP Recorder Supplies Catalog for details of plotter supplies.

Grounding Requirements

To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the plotter be properly grounded. The plotter is equipped with a three-conductor power cable which, when connected to an appropriate power receptacle, grounds the plotter to preserve this protection feature, do not operate the plotter from an ac power outlet which has no ground connection.

Power Requirements

The 7221B and 7221S Plotters have the following power requirements:

- Line Voltage: 100 Vac + 5%, − 10%; 120 Vac + 5%, − 10%; 220 Vac + 5%, − 10%; 240 Vac + 5%, − 10% — Switch Selectable
- Line Frequency: 48 to 66 Hertz
- Line Current: 2.3A @ 100V; 2.1A @ 120V; 1.2A @ 220V; 1.1A @ 240V

Fuses

WARNING

TO AVOID THE POSSIBILITY OF SERIOUS INJURY, DISCONNECT THE AC POWER CORD BEFORE REMOVING OR INSTALLING A FUSE.

There are two ac line fuses which are identified as F1 and F2 in Figure 1-2. Fuse selection is as follows:

	F1	F2
100 or 120 Vac Operation	3 Ampere	0.5 Ampere
220 or 240 Vac Operation	1.5 Ampere	0.25 Ampere

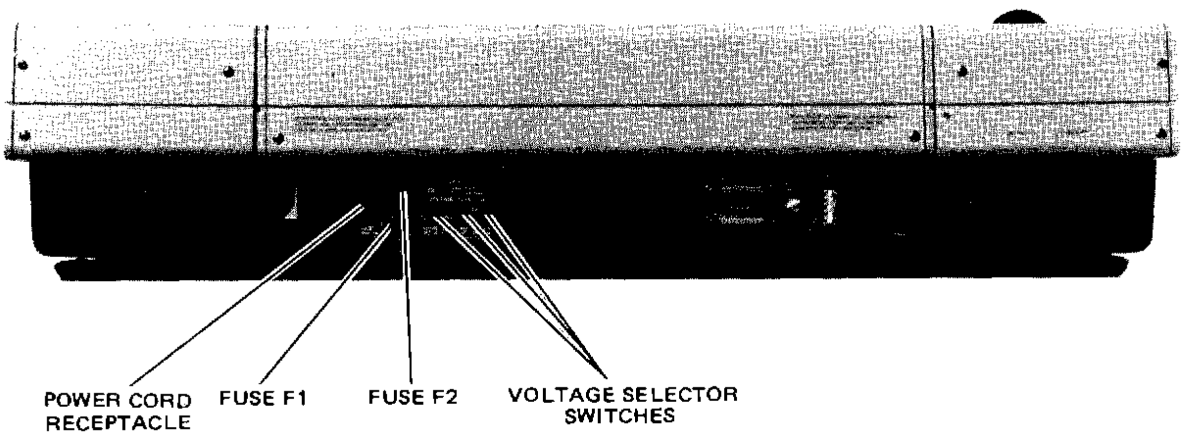


Figure 1-2. Rear Panel Power Controls

To change a fuse, disconnect the power cord. Remove the fuse cap by pressing inward on the center portion of the holder and twist counterclockwise. To reinstall, insert the fuse in the cap and reinstall in the fuse holder. Press on the cap and twist clockwise until the fuse locks in place.

Line Voltage Selection

CAUTION

To prevent damage to the instrument make the line voltage selection BEFORE connecting the line power. Also ensure the line power cord is connected to a line power socket that is provided with a protective earth contact.

Rear Panel VOLTAGE SELECTOR switch settings for the four power sources with which the plotter can operate are shown in Figure 1-3. Set your plotter for the power source to be used.

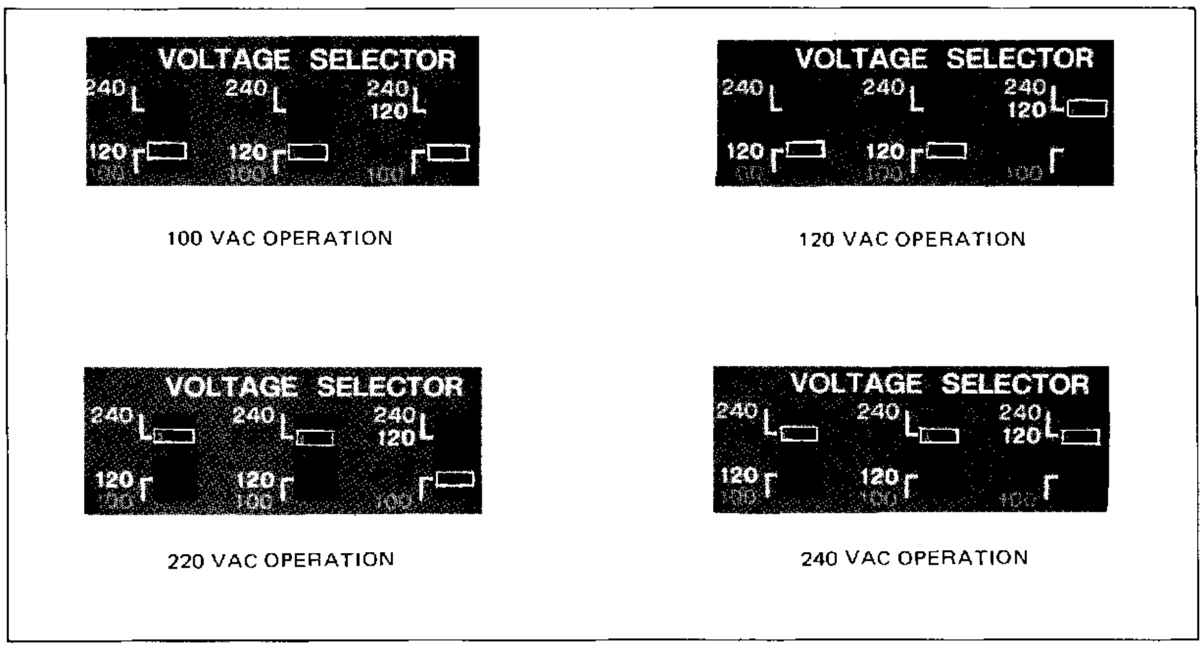


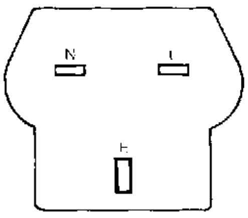
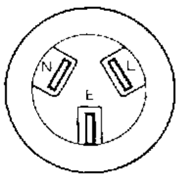
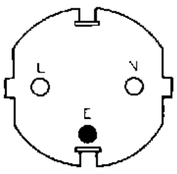
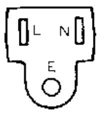
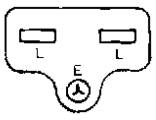
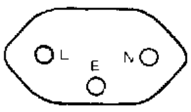
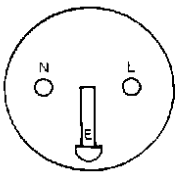
Figure 1-3. Line Voltage Selection

Power Cords

WARNING

IF IT IS NECESSARY TO REPLACE THE POWER CORD, THE REPLACEMENT CORD MUST HAVE THE SAME POLARITY AS THE ORIGINAL. OTHERWISE A SAFETY HAZARD FROM ELECTRICAL SHOCK TO PERSONNEL MIGHT EXIST. IN ADDITION, THE EQUIPMENT COULD BE SEVERELY DAMAGED IF EVEN A RELATIVELY MINOR INTERNAL FAILURE OCCURRED.

Power cords supplied by HP will have polarities matched to the power-input socket on the plotter, as shown on the following page. Various types of HP power cords are shown in Figure 1-4.

		Option Number
BS 1363A 	HP Part Number 8120-1351; 250V, 13A, 1ϕ plug rating. (For use in United Kingdom, Cyprus, Nigeria, Rhodesia, Singapore)	900
AS C112 	HP Part Number 8120-1369; 250V, 10A, 1ϕ plug rating. (For use in Australia, New Zealand)	901
CFE 7 VII 	HP Part Number 8120-2857; 250V, 10/16A, 1ϕ plug rating. (For use in East and West Europe, Saudi Arabia, Egypt)	902
NEMA 5-15P 	HP Part Number 8120-1378; 125V, 15A, 1ϕ plug rating. (UL approved; for use in United States, Canada, Japan, Mexico, Philippines, Taiwan)	903
NEMA 6-15P 	HP Part Number 8120-0698; 250V, 15A, 1ϕ plug rating. (UL approved; for use in United States)	904
SEV 1011 	HP Part Number 8120-2104; 250V, 10A, 1ϕ plug rating. (For use in Switzerland)	906
DHCK-107 	HP Part Number 8120-2956; 250V, 10A, 1ϕ plug rating. (For use in Denmark)	912

NOTE: All plugs are viewed from connector end.

- L = Line or Active Conductor (also called "live" or "hot")
- N = Neutral or Identified Conductor
- E = Earth or Safety Ground

Figure 1-4. Types of Power Cords

Operator Maintenance

Thorough cleaning should be performed periodically. Intervals are determined by the type of operation, local air contamination and climatic conditions. The cleaning should include the following:

a. Dust accumulation on the outside of the plotter can be removed using a dust cloth.

b. The filter should be washed in mild soap and warm water. Dry thoroughly before replacing.

WARNING

NEVER LET WATER STAND ON THE PLATEN SURFACE OR ENTER THE ELECTRICAL PORTION OF THE PLOTTER.

CAUTION

Do not use solvents or silicone based cleaners of any type on the platen.

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c. The platen should be cleaned as follows:

1. Select a cloth that will not scratch the platen surface.
2. Unplug the instrument before beginning to clean the platen.
3. Dampen the cloth with warm water, wring out any excess moisture.
4. Apply cleaner and rub lightly as necessary to clean platen. Commercial cleansers such as Comet® or Ajax® may be used.
5. Rinse platen thoroughly.
6. Wipe away any moisture from the platen surface.

Shipment Information

When the plotter is to be shipped, it is essential that the original packing materials and carton be used. If not available, packing materials and a carton may be ordered through the local Hewlett-Packard sales and service office.

If the plotter is being returned to Hewlett-Packard for any reason, contact the local Hewlett-Packard sales and service office. HP service personnel will provide shipping instructions. Attach a tag to the instrument including the following information:

1. Your Company Name

2. Address

3. Telephone Number

4. Name of person who can be contacted

5. Description of problem and desired service.

Do not include the power cord or other operating accessories if returning the instrument to HP.

Chapter 2
Preparation For Use

Introduction

This chapter contains the following discussions:

- Controls and Indicators
- Pen Installation
- Loading Sheet Paper
- Loading Roll Paper
- Running the Confidence Test
- Plotter Initialization
- Pen Control
- Installation/Operation of the Digitizing Sight
- Setting Graphic Limits
- Entering A Digitized Point
- Suspension/Resumption of Plotting
- Orienting Typed Labels (Local Mode Only)
- Installation/Operation With A Modem and Terminal
- Installation/Operation With A Hardwired Computer and Terminal
- Installation/Operation With A Computer Mainframe
- Installation/Operation With A Terminal

Controls and Indicators

Identification of Plotter controls and indicators is shown in Figure 2-1 and described on the following pages. Controls and functions which apply to both the 7221B and 7221S plotters are given first, followed by those which apply only to the 7221S.

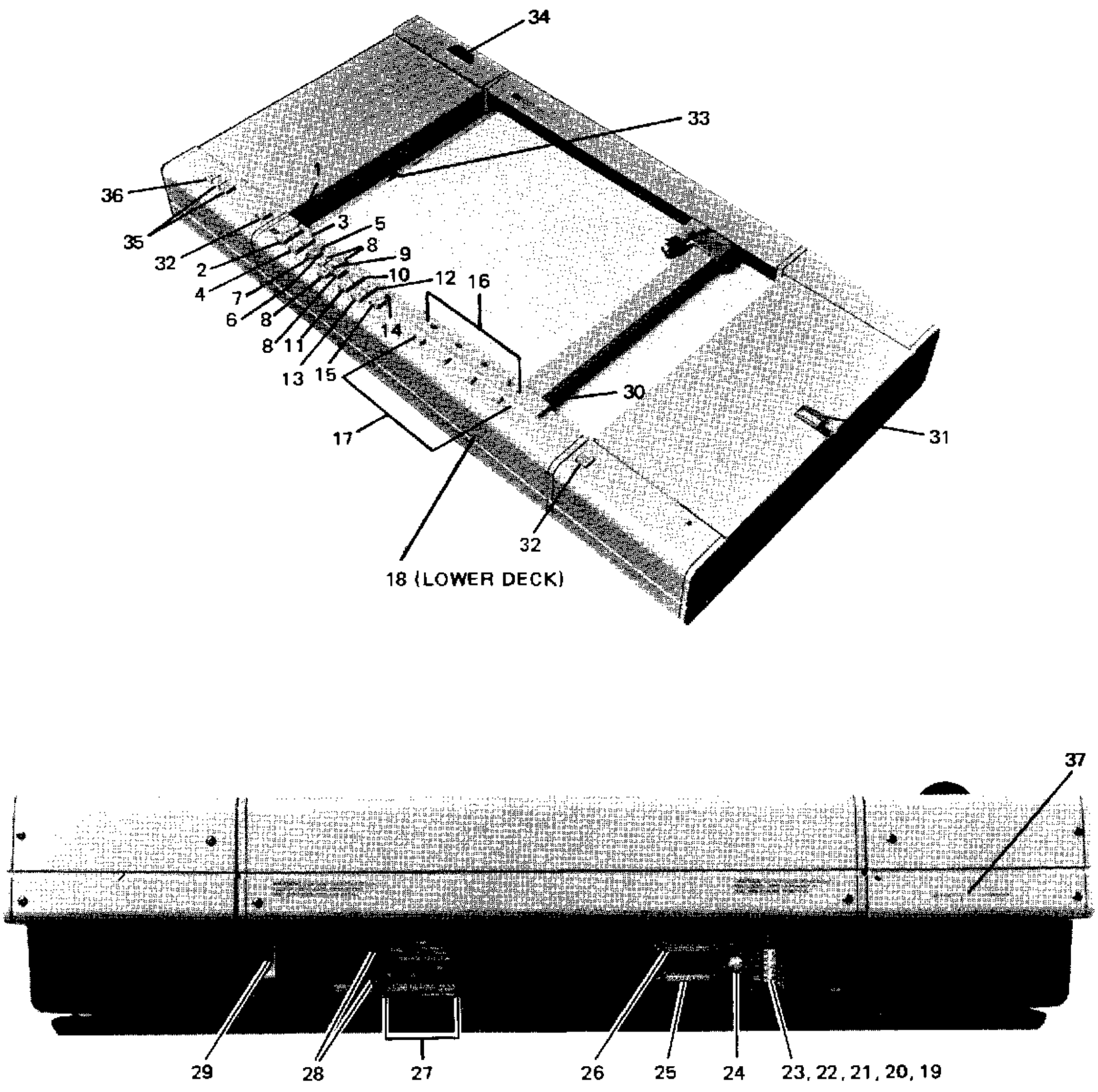
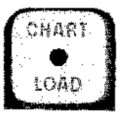


Figure 2-1. Plotter Controls and Indicators

2

CONTROL | FUNCTION

1. 

Pushbutton switch with lamp used to load either roll or sheet paper. When pressed the following occurs:

a. CHART LOAD pushbutton lamp is on steady.

b. OUT OF LIMIT lamp is on steady.

c. Electrostatic paper hold-down is deactivated.

d. Execution of any plot data in the buffer is suspended.

e. Pen is moved to the upper right corner of the platen. Plotter initializes if not done previously.

2. 

Pushbutton switch. When operated the following occurs:

a. Electrostatic paper hold-down is activated. Cannot be activated when using roll paper on the 7221S.

b. CHART LOAD pushbutton lamp, if on, is turned off. Cannot turn off lamp when using roll paper on the 7221S.

c. Execution of plot data in the buffer is suspended while the button is held down. Execution of data resumes when the pushbutton is released.

d. Holding the pushbutton down for more than one second causes the pen to move to the upper right corner of the plotting area, with the pen raised, and execution of plot data in the buffer is suspended. The pen returns to the original position and resumes plotting when the push-button is released.

 and 

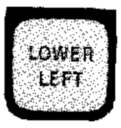
e. If the ENTER pushbutton has been operated first, and the enter lamp is flashing, pressing the CHART HOLD pushbutton causes the plotter to initialize (INIT) and turn off the ENTER lamp.

3. 

Pushbutton switch used to raise the pen and move it to the current upper right plotting limit.

 and 

If the ENTER pushbutton has been operated first, and the ENTER lamp is flashing, pressing the UPPER RIGHT push-button causes the current pen position to be entered as the new upper right plotting limit. The ENTER lamp goes off upon completion of this function.

4. 

Pushbutton switch used to raise the pen and move it to the current lower left plotting limit.

 and 

If the ENTER pushbutton has been operated first, and the ENTER lamp is flashing, pressing the LOWER LEFT push-button causes the current pen position to be entered as the new lower left plotting limit. The ENTER lamp goes off upon completion of this function.

5. 

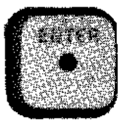
The ERROR lamp blinks if an error occurs in the plotters' internal data handling process. The lamp is turned on steady if one of the following errors occur:

a. Transmission error in the communications link.

b. Syntactical error in an instruction.

c. Data buffer overflow.

The ERROR lamp will turn off when an OUTPUT ERROR instruction is processed or when the plotter is initialized.

6. 

A multi-purpose control used to perform the following functions:

a. Used with the CHART HOLD control to initialize the plotter.

b. Used with the UPPER RIGHT control to establish the upper right graphic limit.

c. Used with the LOWER LEFT control to establish the lower left graphic limit.

d. Used with the pen select pushbutton to store a pen.

e. To enter a digitized point.

f. Used with the arrow controls to orient typed labels in the LOCAL mode.

g. To suspend or resume execution of programmed graphic instructions from the front panel.

7. 

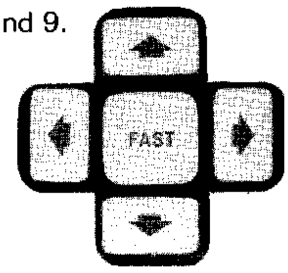
OUT OF LIMIT

The OUT OF LIMIT lamp is turned on steady when the physical or logical graphic position of the plotting pen exceeds defined graphic limits under the following circumstances:

a. When the plotter is initialized.

b. When the pen position (logically or physically) is outside graphic limits as established by front panel or program control.

8. and 9.



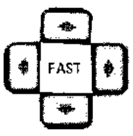
Five pushbutton switches that are used to move the plotting pen within the plotting area. Control functions are as follows:

a. Pressing an arrow pushbutton causes the pen to move in the direction of the arrow at 4.8 mm/second.

b. Pressing an arrow pushbutton in conjunction with the FAST pushbutton causes the pen to move in the direction of the arrow at 93.2 mm/second.

c. Pressing adjacent arrow pushbuttons simultaneously causes the pen to move at a 45° diagonal between the two arrow directions.

d. Pressing opposite arrow pushbuttons simultaneously produces no pen movement in that axis.


and


e. Pressing an arrow pushbutton after the ENTER pushbutton has been operated (the ENTER lamp is blinking) produces no pen movement: additionally, in the LOCAL mode only, a rotation angle is stored in the plotter to cause subsequent plotting functions to be referenced to the direction of the arrow.

10.

A pushbutton switch used to raise the pen from the plotting surface. This control overrides programmed pen control until pushbutton is released.

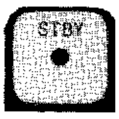
11.

A pushbutton switch used to lower the pen to the plotting surface under the following conditions:

a. If the pen is within graphic limits, the pen remains down until raised by using the PEN UP pushbutton, or under program control.

b. If the pen is at the graphics limit boundary, and the OUT OF LIMIT lamp is on, the pen remains down only while the PEN DOWN pushbutton is held down.

c. Overrides programmed pen control until switch is released.

12. 

A pushbutton switch with lamp that is used to place the plotter in STANDBY. The following events occur in the STANDBY mode:

a. The STBY lamp turns on steady.

b. Execution of buffered instructions in the plotter is halted, and unexecuted instructions in the buffer are purged.

c. Stored macro-instructions and variables remain unchanged.

d. The plotter passes data between the host computer and terminal using plotter microprocessor control, but without scanning for plotter instructions. When the plotter is in the ON LINE or LOCAL mode, a flashing STBY lamp indicates that data is being received.

13. 

A pushbutton switch with lamp that is used to place the plotter in LOCAL mode. When repeatedly pressed, the plotter will be cycled between the programmed "off" and programmed "on" modes, as indicated by the LOCAL lamp being on steady, or flashing, respectively. The following events occur in LOCAL mode:

a. After LOCAL mode is selected, the plotter is connected to the terminal and any further data from a host computer is ignored.

b. After the pushbutton is pressed, execution of any graphics data in the plotter buffer continues uninterrupted until the buffer is empty.

c. Stored macroinstructions and variables in the plotter remain unchanged.

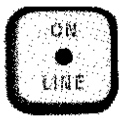
d. If the LOCAL lamp is on steady, the plotter has not received a PLOTTER ON instruction from the terminal or front panel and is programmatically "off". The plotter will not respond to incoming instructions, except PLOTTER ON, in this state.

e. If the LOCAL lamp is flashing, the plotter has received a PLOTTER ON instruction from the terminal or front panel and is programmatically "on". The plotter responds to all device control and graphics instructions in this state.

f. Plotter responses to received output instructions are sent to the terminal.

14. 

The Data Set lamp indicates the state of the modem or host computer when the plotter is connected into a computing system. The lamp is on steady when the Data Set Ready line (refer to Chapter 11) from the modem or host computer is high.

15. 

A pushbutton switch with lamp that is used to place the plotter in the ON LINE mode. When repeatedly pressed, the plotter will be cycled between the programmed "off" and programmed "on" modes, as indicated by the ON LINE lamp being on steady or flashing, respectively. The following events occur in the ON LINE mode.

a. If the ON LINE lamp is on steady, the plotter has not received a PLOTTER ON instruction and is programmatically "off". The plotter will not respond to received device control and graphic instructions, except PLOTTER ON, in this state.

b. If the ON LINE lamp is flashing, the plotter has received a PLOTTER ON instruction from the computer or front panel and is programmatically "on". The plotter responds to device control and graphic instructions in this state.

c. When the ON LINE pushbutton is pressed, execution of graphic instructions in the plotter buffer continues uninterrupted.

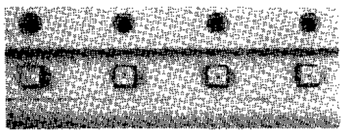
d. Stored macro-instructions and variables in the plotter remain unchanged.

e. Plotter response to output data requests are sent to the computer.

f. Data originating at the terminal is passed to the computer unless "Monitor Mode" is active (refer to Chapter 8).

16. **Pen Stable**

An area provided to house the four plotter pens when not in use. Each stall has an opening in the top of the control panel that provides visual indication of the presence and ink color of the pens not in use.

17. 

Four pen-select pushbutton switches used to select, change or store plotting pens under the following conditions:

a. Operating a pushbutton causes the pen in the pen holder to be stored in its original stall or, if occupied, in the lowest numbered empty stall. The pen in the stall associated with the operated pushbutton is then loaded into the pen holder which returns to the last graphic position with the pen up.

b. If the pen is moving when the pushbutton is operated, the move will be completed before the pens are changed.

c. Execution of buffered data in the plotter is suspended while the plotter is changing pens.

 and 

d. If the ENTER pushbutton is operated before operating a pen-select pushbutton, and the ENTER light is flashing, the pen in the pen holder will be stored in the stall associated with the operated pushbutton if the stall is empty. The empty pen holder then returns to the last graphic position. If the stall associated with the operated pushbutton is full, no pen holder movement occurs.

18. 

Pushbutton switch that controls application of ac power to the plotter. Power is off when the switch is extended (set to) and on when the switch is depressed (set to). The following events occur when the switch is turned on:

a. The pen arm and pen holder move slightly.

b. The plotter is placed in an on-line, programmatically "off" state with the ON LINE lamp on steady (refer to item 15, step a.).

c. The OUT OF LIMIT Lamp turns on steady.

d. The electrostatic paper holddown is turned on. (Cannot be turned on when using roll paper on the 7221S.)

e. The fan motor is running.

19. 

The confidence test (CONF TEST) switch is set to the OFF position during plotter operation. The switch is set to ON to test plotter circuits prior to operation. Refer to the "Confidence Test" discussion in this chapter for details concerning the use of this switch.

20. and 21. 

The parity ON/OFF and EVEN/ODD switches are effective only when the plotter is in the ON LINE mode and programmed "on" by a host computer (or front panel control), or when outputting data to the terminal in LOCAL mode. These switches set the parity checking and generation electronics for use with ODD or EVEN parity as established by system requirements. If parity is not used, the PARITY ON/OFF switch is set to OFF, and the setting of the EVEN/ODD switch is irrelevant.

22. 

The DUPLEX HALF/FULL switch is used only when the plotter is set for LOCAL mode or with "monitor mode" active during on-line operation.

During LOCAL mode operation the switch function is as follows:

a. When set to FULL, the plotter returns (echoes) data received from the terminal back to the terminal.

b. When set to HALF, the echo is suppressed.

During ON LINE mode operation, with "monitor mode" active, the DUPLEX switch function is as follows:

a. When set to FULL, and computer is working in an echoplex environment, all plotter output responses are echoed from computer, through plotter to terminal.

b. When set to HALF, all plotter output responses are sent to both the computer and the terminal. All data received from the computer is also sent to the terminal.

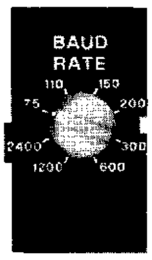
2

23. 

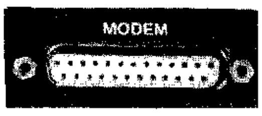
The MODEM/HARDWIRE switch is effective only at plotter power-on. This switch determines the initialized state of the "Hardwired Handshake" and "Enable Data Transmission" options of the SET PLOTTER CONFIGURATION instruction (refer to Chapter 8).

When the switch is set to MODEM, the "Hardwired Handshake" and "Enable Data Transmission" options are initialized to the "OFF" state.

When the switch is set to HARDWIRE, the "Hardwired Handshake" and "Enable Data Transmission" options are initialized to the "ON" state.

24. 

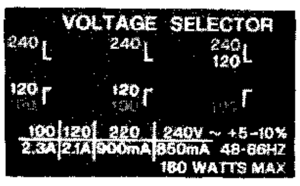
An eight-position selector switch that is used to set the plotter electronics for operation with data transmission rates of 75, 110, 150, 200, 300, 600, 1200 or 2400 baud as required by the system.

25. 

The MODEM connector is a 25-pin, female type that is RS-232-C/CCITT V.24 compatible. The connector is used to interconnect the plotter with a modem or host computer.

26. 

The TERMINAL connector is identical to the MODEM connector and is used to interconnect the plotter and a terminal.

27. 

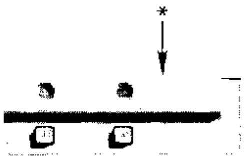
Three two-position slide switches that are used to set the plotter for use with 100, 120, 220 or 240 Vac primary power (refer to Chapter 1).

28. 

AC line fuses (refer to Chapter 1).

29. 

Power cord receptacle (refer to Chapter 1).

30. 

*Sensing stall. Location of bottom limit switch which is used during plotter initialization.

The following pertain only to the 7221S plotter.

31. 

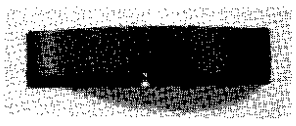
Roll paper gauge. Calibrated in quarters of a roll.

32. 

Pushbuttons to release cover on right and left roll paper supply modules.

33. 

Paper stop. Must be recessed while roll paper is in use and raised for sheet paper. The stop is raised by pressing down on the paper stop in the upper port.

34. 

Paper advance thumbwheel to adjust tension on newly loaded roll paper or to advance roll paper manually.

35. 

Pushbutton switches to advance roll paper one half page or one full page from the left edge of the platen. These switches are operative only when roll paper is loaded (paper advance option is "on").

The following associated events will occur when either of these switches is pressed.

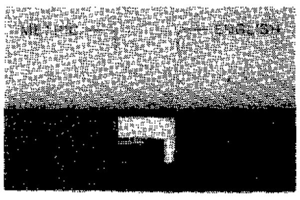
a. The execution of programmed graphic instructions is suspended and the pen is moved to the "sensing" stall before the paper is advanced (refer to item 30). After the advance, the limit switches re-establish the X and Y coordinates and the pen is then returned to its last position prior to the advance and plotting of data in the buffer resumes.

b. If the CUTTER ENABLE lamp is on steady, the paper will be cut after each advance. The cut is made at the point which was concident with the left edge of the platen when the advance was initiated.

36. 

A pushbutton switch with lamp that is used to enable and disable the roll paper cutter. The state of the cutter is "on" when the CUTTER ENABLE lamp is on steady and "off" when the lamp is off. The default and power-up state of the cutter is "on".

If the cutter is "on", the paper is cut only after it has been advanced either a half page or a full page. The location of the cut is along the line which coincides with the left edge of the platen at the time the advance operation is initiated.

37. 

This switch is used to control the length of paper advance and also determines power-up and default graphic limits if the paper advance option is "on". The paper advance option is "on" if roll paper is loaded and tensioned across the platen so that the two paper sensor switches are activated. Refer to "Setting Graphic Limits" in this chapter and in Chapter 4 for a definition of default graphic limits. Paper advance length and default graphic limits are as follows:

a. Switch set to METRIC
   - Half page length = 210 mm
   - Full page length = 420 mm
   - Lower left X,Y = 520, 1140 machine units
   - Upper right X,Y = 15720, 11140 machine units

b. Switch set to ENGLISH
   - Half page length = 8.5 inches
   - Full page length = 17 inches
   - Lower left X,Y = 520, 1020 machine units
   - Upper right X,Y = 15760, 11180 machine units

Pen Installation

Pens are manually loaded in the pen stable using the following procedures:

a. Check that the LINE switch is off (set to 0).

b. Manually move the plotter arm to the left edge of the platen.

c. Select the pen (by color) to be loaded in stall 1 of the pen stable, and remove the pen cap.

d. Insert the tip of the pen into the rubber cap located at the bottom of the pen stall as shown in Figure 2-2.

e. Push the pen into the stall by exerting slight downward and forward pressure on the top of the pen.

f. Repeat the foregoing procedures until the four pen stalls are full.

g. Check that the power cord is connected and set the LINE switch on (set to 1).

h. Load the pen holder by pressing the Pen Select pushbutton associated with the pen to be used.

An alternate method of loading pens is as follows:

WARNING

The operator's hands should be clear of the pen stable at all times when using this method of loading pens.

---

a. Check that the LINE switch is off.

b. Load the desired pen in the pen holder as shown in Figure 2-3.

c. Set the LINE switch on.

d. Press the ENTER pushbutton. The lamp should start flashing.

e. Press the Pen Select pushbutton associated with the stall into which the pen is to be loaded. The pen arm and pen holder automatically loads the pen into the selected stall.

f. Repeat the foregoing steps to load the remaining three stalls.

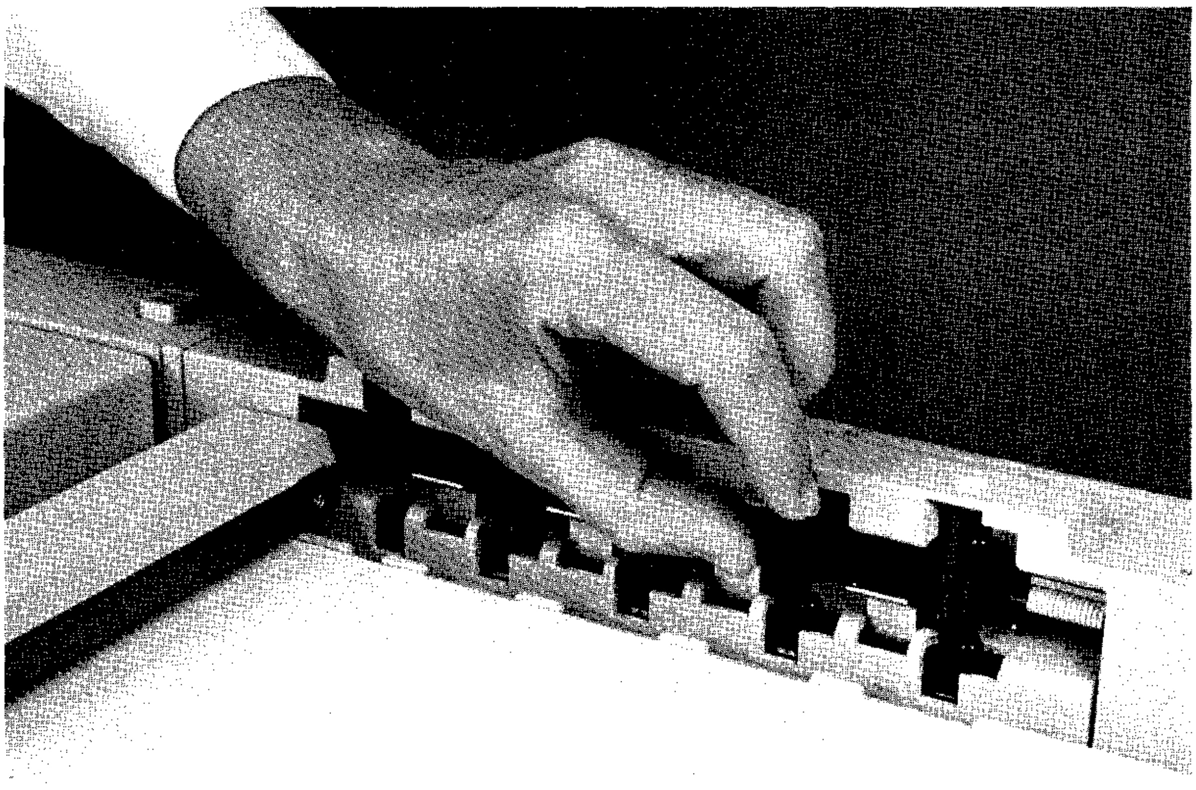


Figure 2-2. Pen Stable Loading

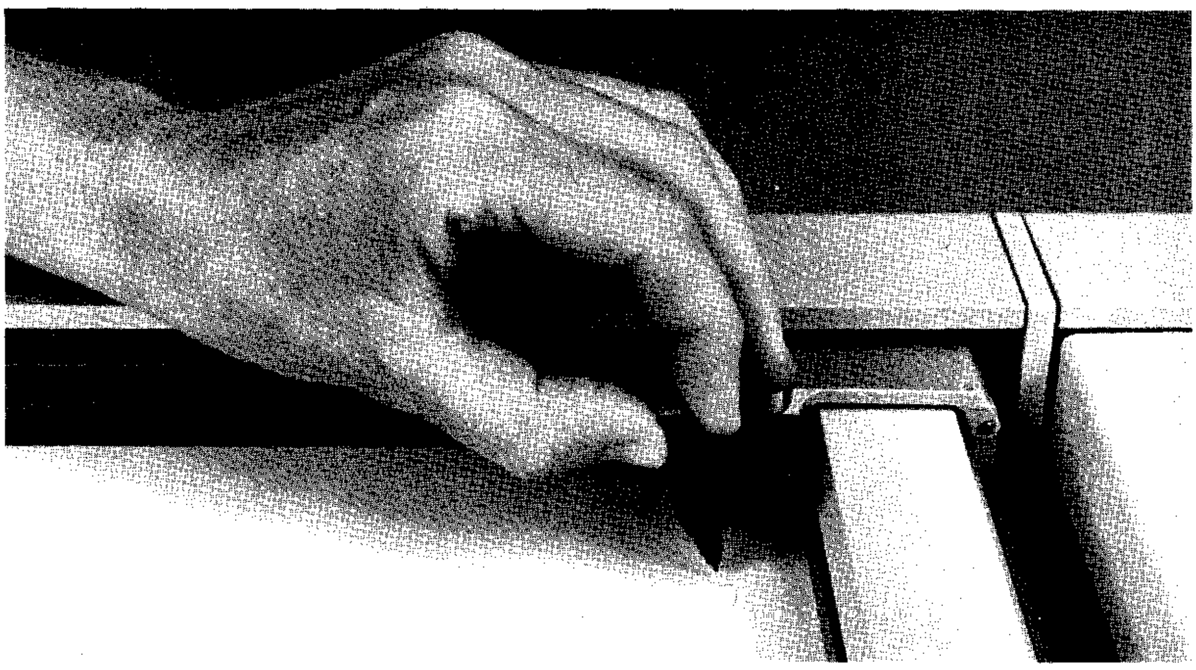


Figure 2-3. Pen Holder Loading

Loading Roll Paper (7221S Only)

WARNING

To avoid the possibility of injured fingers, always turn off the plotter before loading roll paper.

To load roll paper, proceed as follows (refer to Figure 2-4):

a. Set the LINE switch to off.

b. Remove pen from pen arm holder to avoid getting ink on the new paper.

c. Depress paper stop on left side of the platen.

d. Press DOOR LATCH pushbuttons and open both the take-up module and supply module.

e. Position roll paper between hubs in supply module and align hub tabs with roll notches.

f. Align front edge of paper with front edge of platen and feed paper across table and under pen arm.

g. Engage paper sprocket holes on sprockets at each end of tension roller. Hold paper on roller while closing take-up module door.

h. Close supply module door. Make sure paper is not on top of paper guide at front edge of platen.

i. Advance paper with thumbwheel until tensioned.

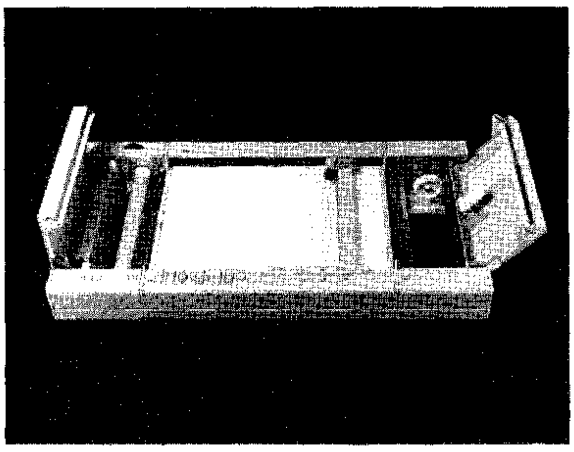
j. Set the METRIC/ENGLISH switch to correspond with loaded roll paper.

k. Set the LINE switch to on.

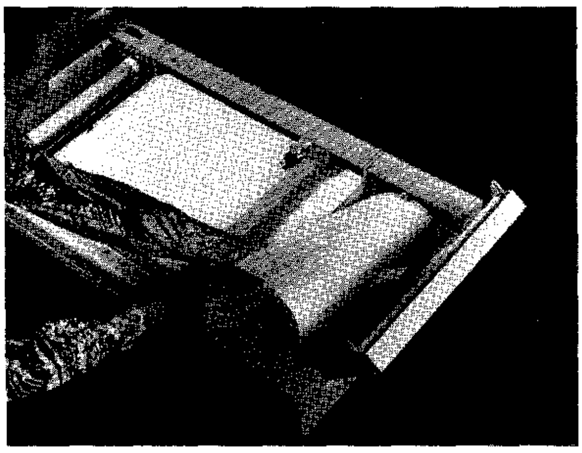
l. Press ADV HALF pushbutton and note that paper is advanced a half page.

NOTE

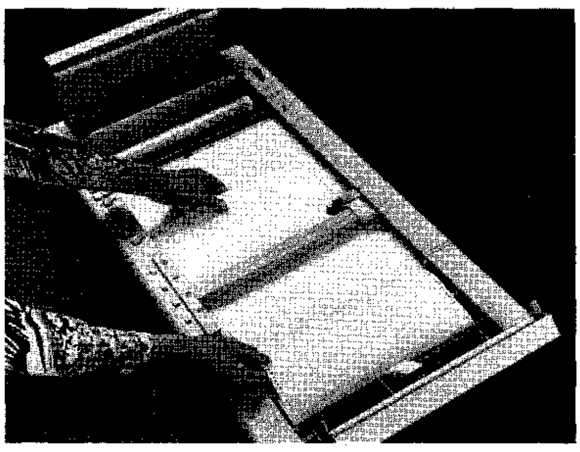
Proper loading of roll paper will turn-on the paper advance option.



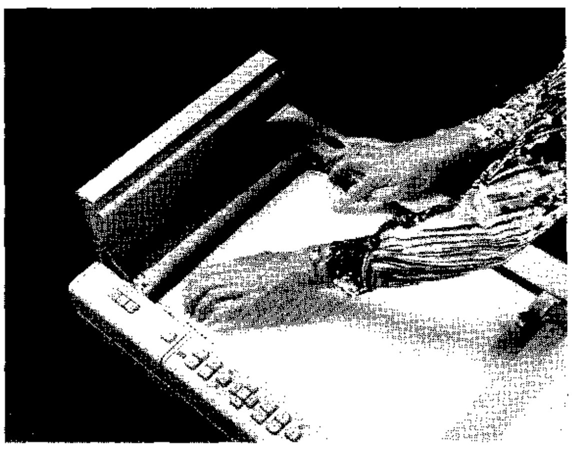
OPEN TAKE-UP
AND SUPPLY MODULES



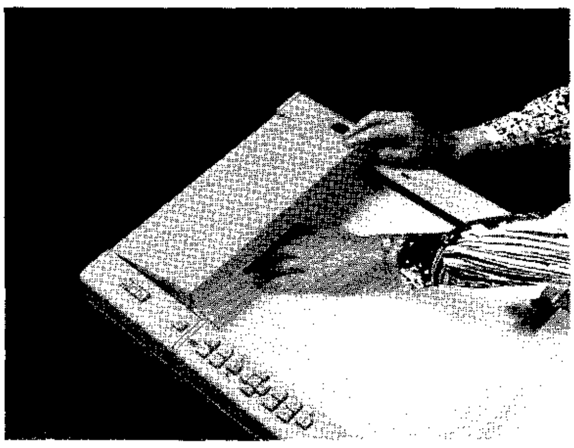
LOADING PAPER IN
SUPPLY MODULE



THREADING PAPER
ACROSS PLATEN



ENGAGING PAPER
HOLES ON SPROCKETS



HOLDING PAPER
ON TENSION ROLLER

Figure 2-4. Loading Roll Paper (7221S only)

Loading Sheet Paper

To load sheet paper, proceed as follows:

a. Set the switch on.

b. Press CHART LOAD . The CHART LOAD and OUT OF LIMIT lamps should go on steady and the pen holder is moved to the upper right corner of the platen.

c. Place sheet paper on platen so that the lower edge is under the lips of the nylon paper stop, then move paper to the left so that the paper is snug against the left paper stop (see Figure 2-5).

d. Press the CHART HOLD pushbutton and smooth out any ripples using the back of your hand with left-to-right motion. The CHART LOAD lamp should go out and the OUT OF LIMIT lamp should stay on steady.

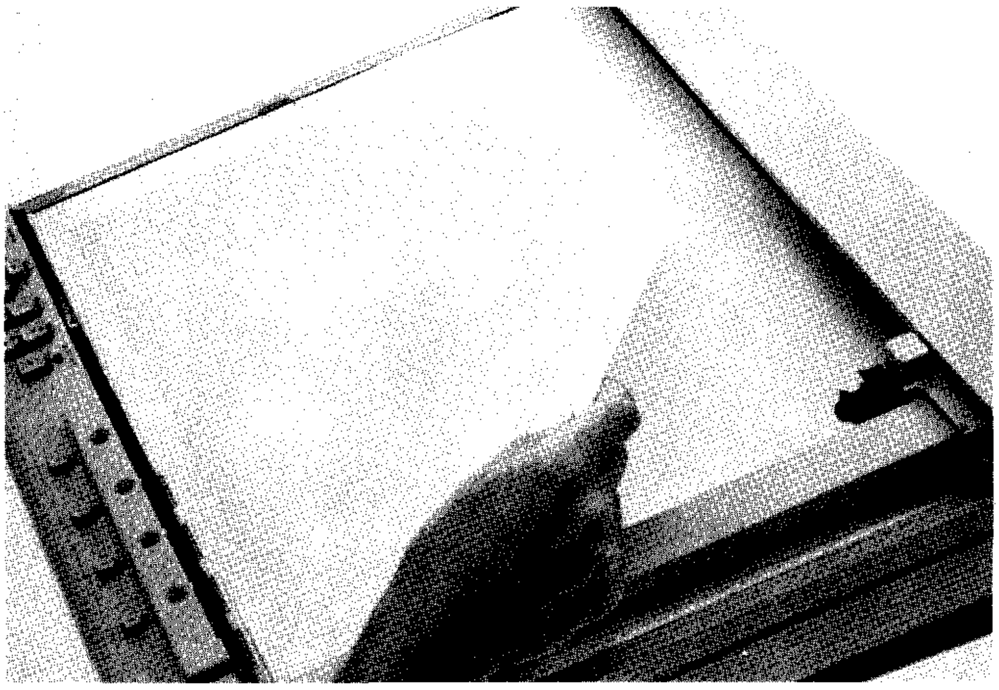


Figure 2-5. Loading Sheet Paper

Running The Confidence Test

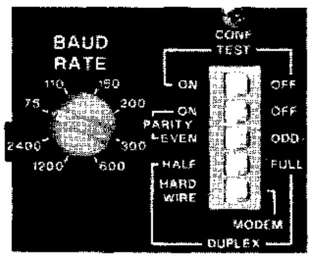
2

A confidence test is included in the plotter firmware to verify that the unit is operating correctly. Prior to the performance of this test have a pen in the pen holder and sheet or roll paper loaded. Proceed as follows:

a. Set the switch off.

b. Connect the RS-232-C/CCITT V.24 male-to-male interface cable (HP Part No. 07221-60157) supplied with the plotter between the rear-panel TERMINAL and MODEM connectors as shown in Figure 2-6.

c. Make rear panel switch settings as follows:



CONF TEST	ON
PARITY	OFF
EVEN/ODD	IRRELEVANT
DUPLEX	IRRELEVANT
BAUD RATE	ANY
MODEM/HARDWIRE	IRRELEVANT

d. Set the switch on.

The plotter performs an initialization sequence (see plotter initialization), then the confidence test runs and performs the following functions in sequence:

a. OUT OF LIMIT DATA SET ON LINE lamps are on steady.

b. The plotting pen is moved to the lower right corner of the platen then moves to the lower left corner.

c. ON LINE lamp turns off.

d. STBY lamp turns on steady.

e. The plotter performs a self-test of various internal circuits. During this time the plotting pen does not move. This portion of the test takes approximately 3 seconds.

f. DATA SET lamp flashes 3 times.

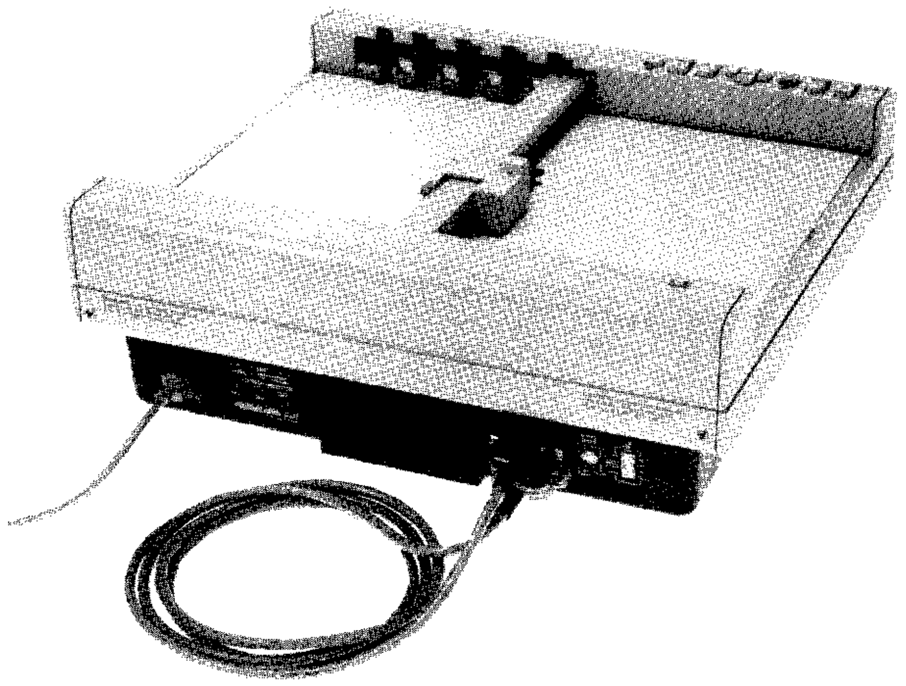


Figure 2-6. Plotter Confidence Test Connections

g. The plotter executes the confidence test plot illustrated in Figure 2-7.

h. The plotting pen returns to the lower left corner of the platen with the pen down.

i. The following lamps go on steady:

CHART LOAD   ERROR   ENTER   OUT OF LIMIT   LOCAL   ON LINE

j. The following lamps are off:

DATA SET   STBY

NOTE

If a failure occurs while the confidence test is running, or if improper results are obtained, refer the problem to qualified service personnel.

This concludes the confidence test. Set the LINE and CONF TEST switches off. Disconnect the RS-232-C/CCITT V.24 cable from the TERMINAL and MODEM connectors.

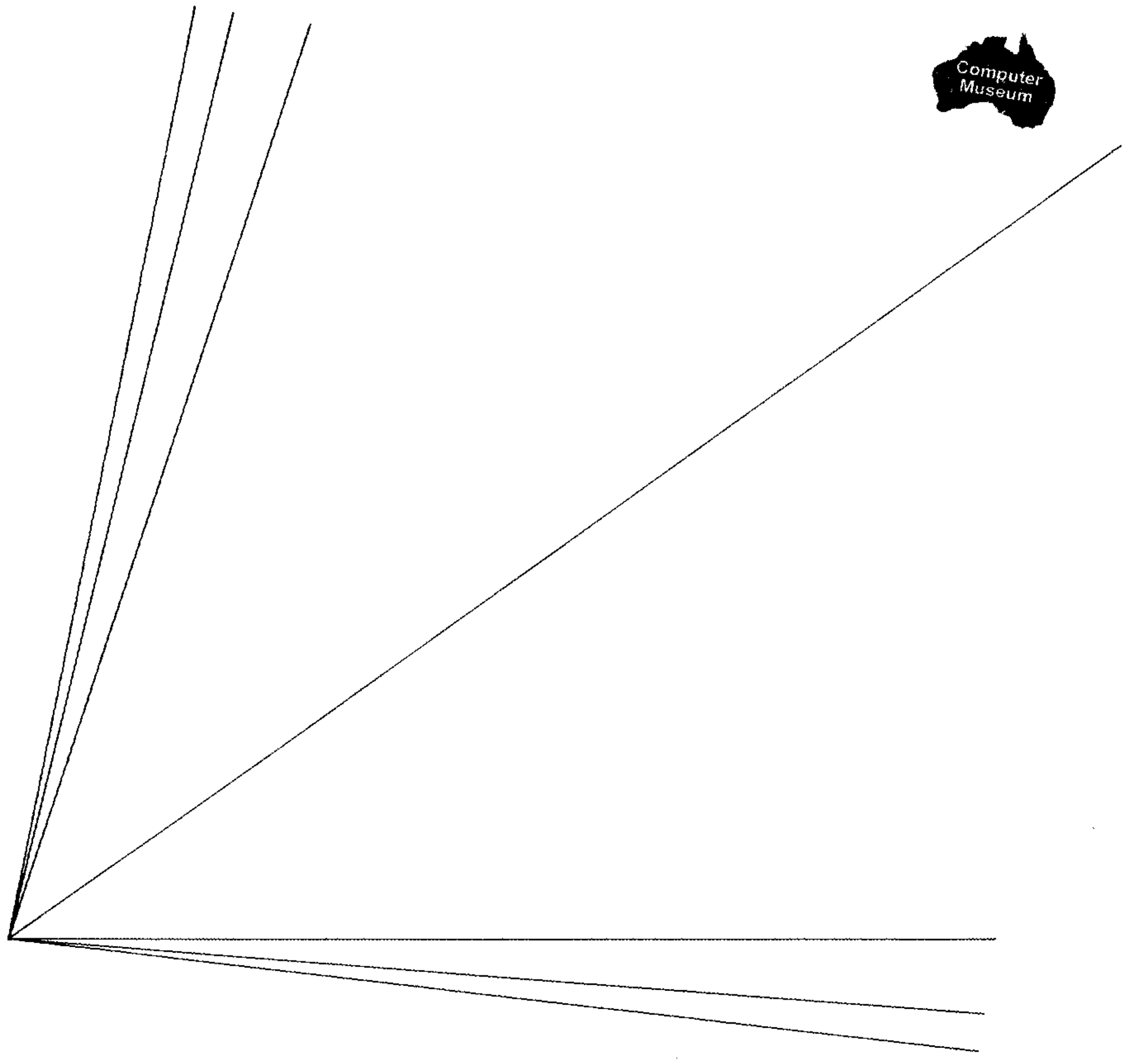


Figure 2-7. Confidence Test Plot

Plotter Initialization

Initialization sets the plotter to a predetermined logical and mechanical state. The plotter comes to the initialized state, except for the establishment of mechanical limits, when the LINE switch is turned on. Mechanical limits, however, will not be established until some plotting pen movement is required. This can be done under program control (refer to the INITIALIZE instruction in Chapter 10) or under local control using the following procedures:

a. LINE switch on. The OUT OF LIMIT ON LINE lamps go on steady.

b. Press ENTER. Lamp starts flashing.

c. Press INIT CHART HOLD. The ENTER lamp goes out.

d. The pen arm moves toward the right of the platen until it encounters the far-right limit switch.

e. The pen holder moves down until it encounters the bottom limit switch in a stall adjacent to the pen stable.

f. The pen holder moves out of the limit switch stall and stops in the lower-right corner of the platen.

This completes plotter initialization, and internal graphic variables are set to their default values (values assumed by the plotter in the absence of an actual instruction). Refer to the INITIALIZE instruction in Chapter 10 for a list of these default values.

Pen Control

Selecting A Pen

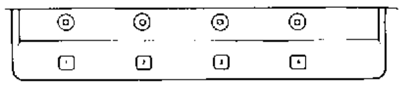
NOTES

If all pen stalls are full when a pen-select pushbutton is operated, the pen holder moves to the stall adjacent to the pen stable in the lower right corner of the platen to sense if there is a pen in the pen holder. If there is, the pen holder moves back to the original position. With four pens in the stable and one in the holder, pens cannot be interchanged.

If the stall associated with the operated pushbutton is empty, no pen selection occurs and the pen holder remains stationary.

Front panel pen selection events occur as follows:

a. Press the desired pen-select pushbutton.



b. Execution of graphic instructions in the buffer is suspended.

c. The pen in the holder is put into its original stall, if empty, or the lowest numbered vacant stall.

d. The pen in the stall associated with the pushbutton is loaded into the pen holder.

e. The pen holder moves back to its original position.

f. Execution of graphic instructions stored in the buffer resumes.

Storing A Pen

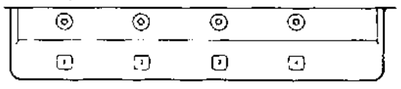
NOTE

If the stall associated with an operated pen-select pushbutton is occupied, no attempt is made to store the pen and the pen holder remains in the last graphic position.

To store a pen proceed as follows:

a. Press [ENTER •]. The lamp starts flashing.

b. Press the desired pen-select pushbutton.



c. The pen in the pen holder is stored in the selected stall.

d. The pen holder is returned to its original position.

e. The [ENTER •] lamp goes out.

Pen Up/Pen Down Controls

NOTES

When a pen is out of graphic limits established by local or program control (• OUT OF LIMIT lamp on steady), the pen will not stay down when the PEN DOWN pushbutton is operated.

When operating under program control, the pen will automatically lift approximately 16 seconds after the last programmed pen instruction is completed.

To raise the operating pen: Press [PEN UP]

To lower the operating pen: Press [PEN DOWN]

Pen Positioning

The arrow and FAST pushbuttons are used to manually position the plotting pen on the platen surface as follows:

a. Press [↑]. Moves the pen toward the top of the platen at 4.8 mm/second.

b. Press [→]. Moves the pen right at 4.8 mm/second.

c. Press [↓]. Moves the pen toward the bottom of the platen at 4.8 mm/second.

d. Press [←]. Moves the pen left at 4.8 mm/second.

e. Press [FAST] and any arrow pushbutton. Moves the pen in the direction of the arrow at 93.2 mm/second.

f. Press [↑] and [→] simultaneously. Moves the pen in a 45° diagonal toward the upper right at 4.8 mm/second.

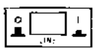
g. Press [↓] and [→] simultaneously. Moves the pen in a 45° diagonal toward the lower right at 4.8 mm/second.

h. Press [↑] and [←] simultaneously. Moves the pen in a 45° diagonal toward the upper left at 4.8 mm/second.

i. Press [↓] and [←] simultaneously. Moves the pen in a 45° diagonal toward the lower left at 4.8 mm/second.

Installation/Operation Of The Digitizing Sight

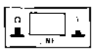
A digitizing sight (HP Part No. 09872-60066) is supplied with the plotter and is installed and operated as follows:

a. Check that the  switch is off.

b. Manually move the plotter arm to the left edge of the platen.

c. Insert the small end of the sight onto the rubber cap at the bottom of the pen stall selected for use. (Refer to Figure 2-2.)

d. Push the sight into the stall using slight downward and forward pressure on the top of the sight.

e. Set the  switch on.

f. Load the pen holder by pressing the Pen Select pushbutton associated with the stall in which the digitizing sight is loaded.

g. Position the sight over the area to be viewed using the previously described pen positioning controls.

h. Operate the PEN DOWN control to lower the sight onto the platen for best viewing results.

Setting Graphic Limits

Graphic limits can be set using the front panel controls, or under program control (refer to "Setting Graphic Limits" in Chapter 4). Once graphic limits are established, plotting can only be done within the boundaries defined by these limits. A new set of graphic limits, whether established by front panel or program control, supersedes and replaces the current set of limits. Figure 2-8 illustrates three plotter limits that affect plotting. If no graphic limits are supplied by the user, the plotting area is within the default graphic limits as defined in the illustration.

NOTE

Always set the lower left limit before the upper right. The upper right graphic limit moves with the lower left limit.

Operating The Lower Left/Upper Right Controls

To set graphic limits proceed as follows:

a. Move the plotting pen to the desired lower left (LL) position using the arrow and FAST pushbuttons.

b. Press [ENTER •]. The lamp starts flashing.

c. Press [LOWER LEFT]. The ENTER lamp goes out.

d. Move the plotting pen to the desired upper right (UR) position using the arrow and FAST pushbuttons.

e. Press [ENTER •]. The lamp starts flashing.

f. Press [UPPER RIGHT]. The ENTER lamp goes out.

These functions store the selected lower left and upper right positions as the new graphic limits. These limits replace the previously selected graphic limits. To check the new limits:

a. Press [LOWER LEFT]. The plotting pen should move to the new lower left position.

b. Press [UPPER RIGHT]. The plotting pen should move to the new upper right position.

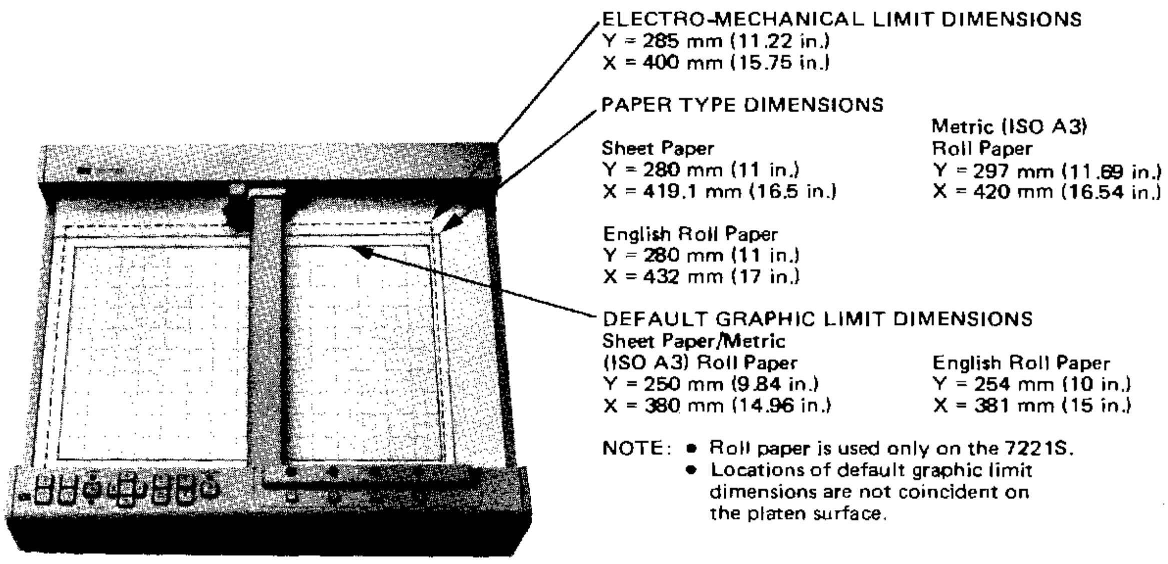


Figure 2-8. Plotter Limits

Paging

The upper right limit moves proportionately when the lower limit is changed. This feature can be used advantageously in applications such as paging (preparing two equal-size pages on the normal 11 in. x 17 in. sheet paper). Figure 2-9 illustrates this function. The lower left (LL) and upper right (UR) graphic limits are established for the left-hand page using the procedures previously listed. When plotting is completed on the left-hand page, the new LL limit is selected for the right-hand page. The UR limit moves proportionately and automatically establishes the upper right limit for the second page.

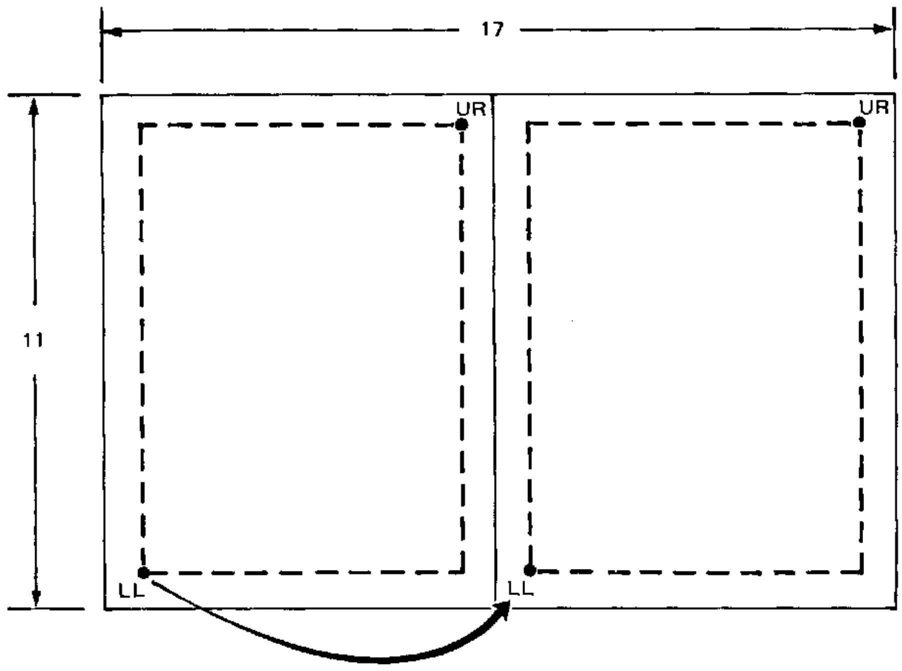


Figure 2-9. Plotter Paging

Graphic Limit Squeezing

When graphic limits are established within the plotting area, and then moved so that one limit intersects a mechanical boundary, a new graphic limit is established at the point of intersection. Figure 2-10 illustrates this operation.

DETAIL A: Illustrates a plotting area defined by the lower left (LL) and upper right (UR) graphic limits.

DETAIL B: Illustrates moving the LL graphic limit to a new position. The UR graphic limit moves proportionately until the mechanical limits are reached. This point is established as the new UR graphic limit.

DETAIL C: Illustrates moving the LL graphic limit back to its original point. The LL and UR limits maintain the same relationship established in Detail B, thus providing a "squeezed" plotting area.

Images

Images of a normal plot can be obtained by repositioning the lower left and upper right graphic limits, either by front panel or program control. Figure 2-11 illustrates four plots obtained using the front-panel controls.

NOTE

In Details B, C, and D the lower left graphic limit (LL) was always set before proceeding to the UR position regardless of the selected LL position.

DETAIL A: Illustrates a normal plot with the LL and UR limits set at default values.

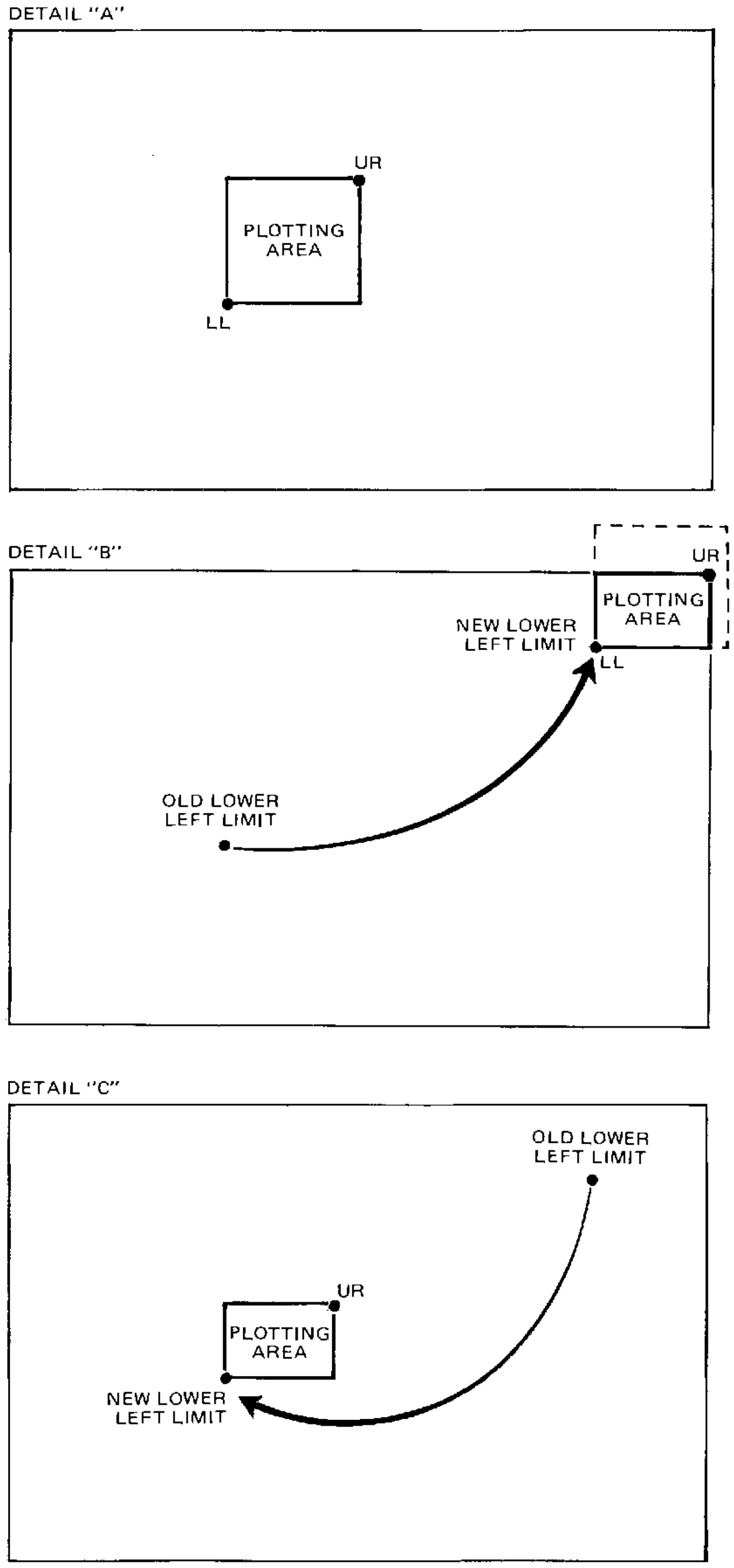


Figure 2-10. Graphic Limit Squeezing

2

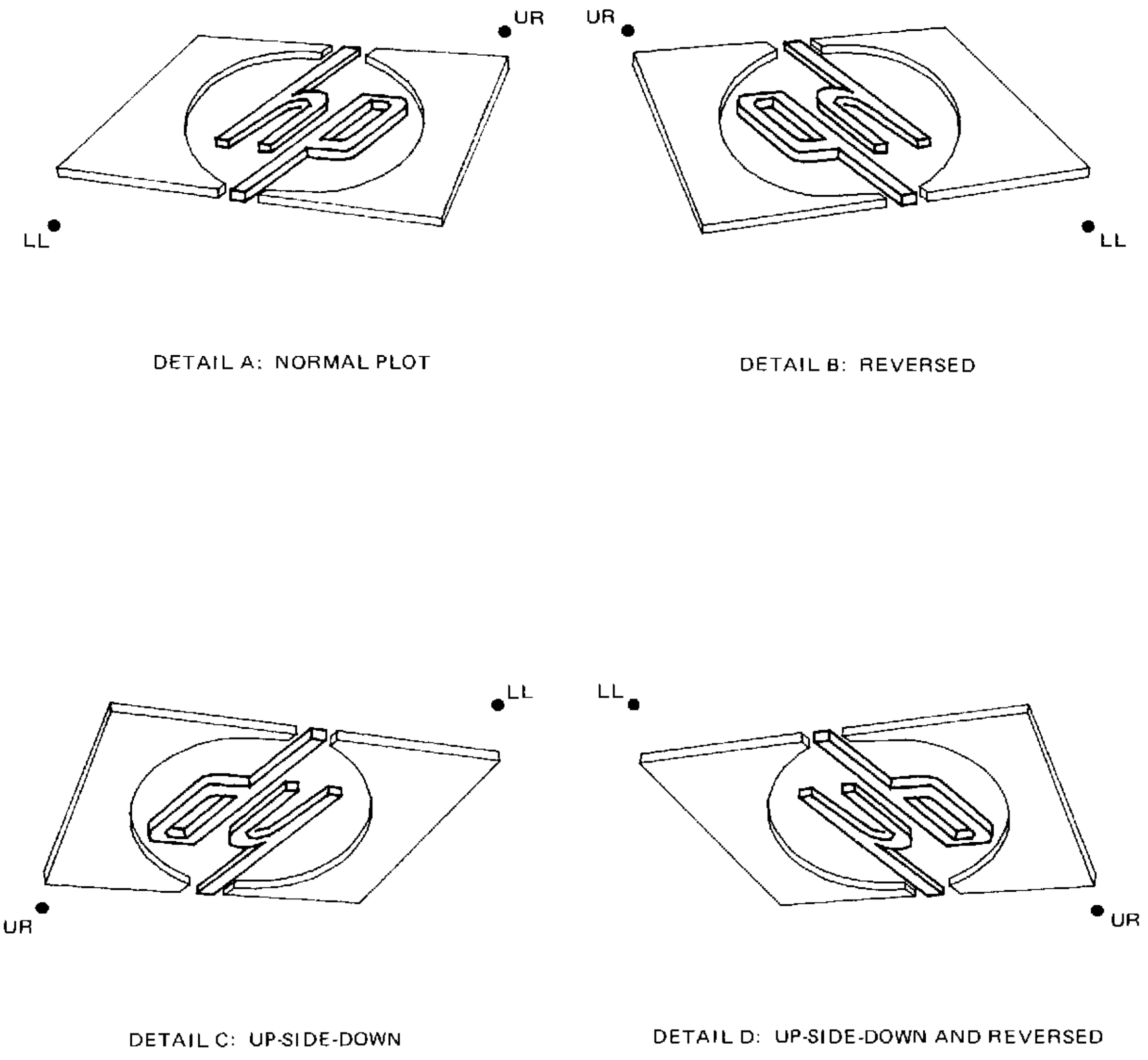


Figure 2-11. Plotter Images

DETAIL B: Illustrates a reversed plot. The LL graphic limit is set at the lower right default limit, and the UR graphic limit at the upper left default limit.

DETAIL C: Illustrates an up-side-down plot. The LL and UR graphic limits are interchanged with the normal positions (DETAIL A).

DETAIL D: Illustrates an up-side-down and reversed plot. The LL graphic limit is set at the upper left default limit and the UR graphic limit at the lower right default limit.

Entering A Digitized Point

When the plotter is operating under program control, response to an OUTPUT DIGITIZED POINT instruction is made from the front panel as follows:

a. The ENTER lamp should be on **steady** indicating that an OUTPUT DIGITIZED POINT instruction has been received by the plotter.

b. Press ENTER . The lamp should go out.

c. If within limits, the current pen position is output as a digitized point.

NOTE

If the current pen position is physically or logically out-of-limits (the OUT OF LIMIT lamp on), then attempts to digitize are ignored and the ENTER lamp remains on.

Suspension/Resumption Of Plotting

When the plotter is being operated under program control, two methods of suspending then restarting the execution of graphic instructions can be used as follows:

a. Using the ENTER • control:

1. Press, then release the ENTER • pushbutton. Plotting is suspended and the ENTER lamp starts flashing.

2. To resume plotting, press the flashing ENTER • pushbutton. Plotting should start and the ENTER lamp goes out.

b. Using the CHART HOLD control:

1. Press and hold the CHART HOLD pushbutton. Plotting is suspended and the pen holder is moved to the upper right corner of the platen.

2. Release the CHART HOLD pushbutton. The pen holder is moved back to its original position and plotting resumes.

Orienting Typed Labels (Local Mode Only)

When operating with a terminal in LOCAL mode, labels can be referenced in the direction of the arrow pushbuttons as follows:

a. Press ENTER • . The ENTER lamp starts flashing.

b. Press the arrow pushbutton for the desired label direction. No pen movement occurs and the ENTER lamp goes out.

c. A rotation angle is stored in the plotter to cause subsequent plots to be referenced in the direction of the arrow pushbutton operated in step b.

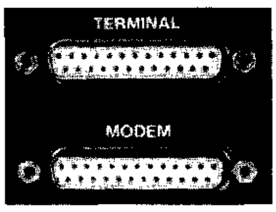
Installation/Operation With A Modem And Terminal

Installation

The plotter can be connected to a remote computing facility through a data set (modem) and hardwired to a terminal to complete the plotting system. In this type installation, the plotter is connected in series between the modem and terminal as shown in Figure 2-12. Rear-panel connections are made as follows:

Terminal to

Modem to



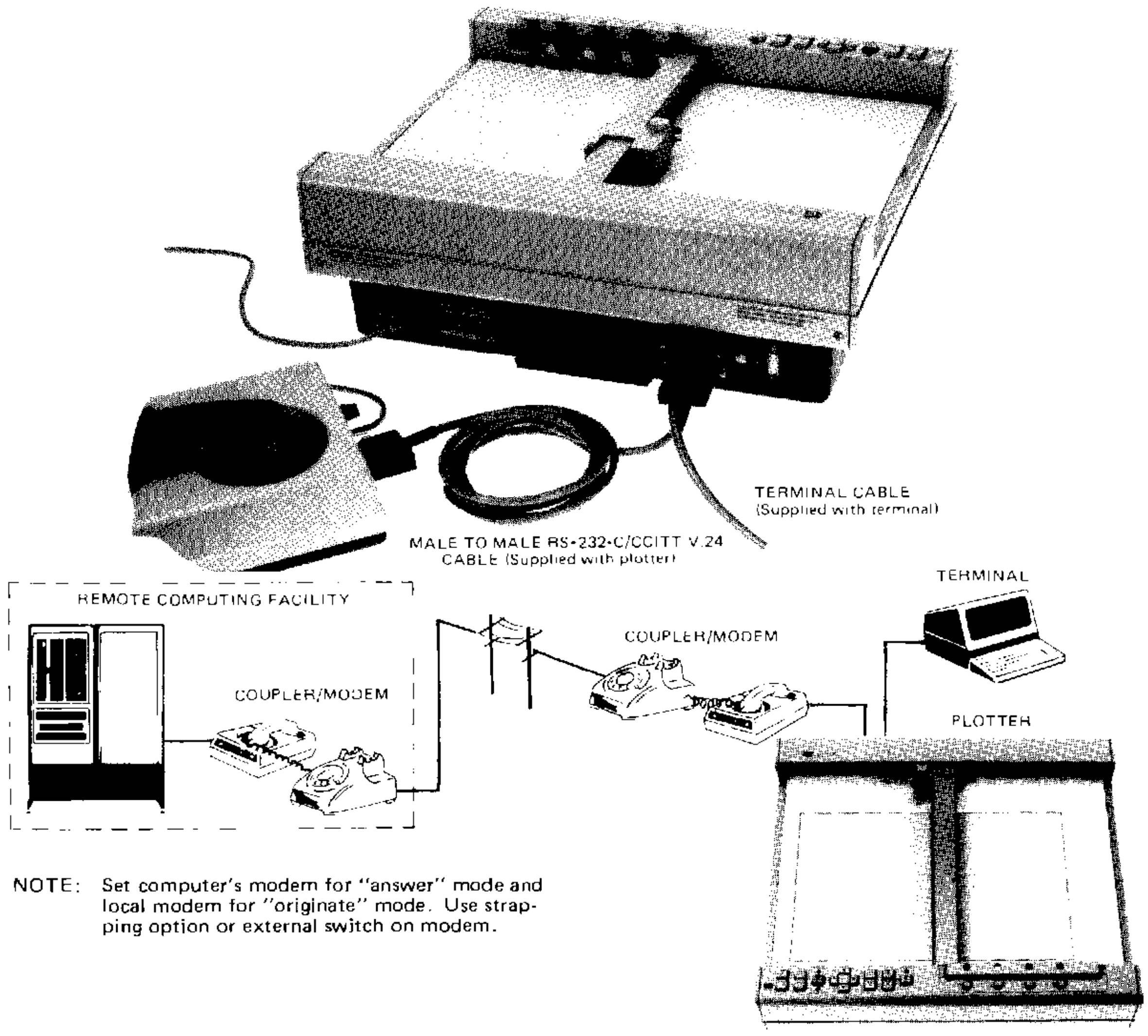


Figure 2-12. Plotter Interconnection with a Terminal and Remote Facility Using Modems

2

Operation

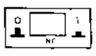
Six modes of operation are available when the plotter is connected in this type system. The modes and control settings are as follows:

Power Off Mode

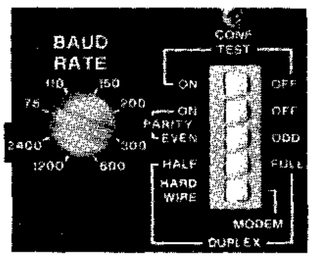
In this mode the plotter passes data between the host computer and terminal using relay closures. Plotter front and rear panel control settings are irrelevant.

Standby Mode

In this mode the plotter passes data between the host computer and terminal under plotter control, but all other plotter circuits are passive. Front and rear panel control settings are:

Front panel		on (to "1")
Press		on. Lamp on steady.
		off and lamp off.
		off and lamp off.
	DATA SET	On steady if the Data Set Ready line from the modem is high (active).

Rear Panel



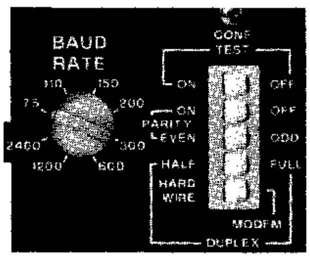
CONF. TEST:	OFF
PARITY ON/OFF:	Irrelevant
PARITY ODD/EVEN:	Irrelevant
DUPLEX:	Irrelevant
BAUD RATE:	Same as host computer/terminal
MODEM/HARDWIRE:	MODEM (Refer to Chapter 10.)

On Line and Programmed Off Mode

In this mode the plotter passes data between the host computer and terminal under plotter control. The plotter automatically enters this mode when power is applied to the unit, and remains in this mode until a PLOTTER ON instruction is received from the host computer or front panel. Front and rear panel settings are:

Front panel	LINE	On (to "1")
	STBY	Off and lamp off
	LOCAL	Off and lamp off
	ON LINE	On and lamp on steady
	DATA SET	On steady if modem's Data Set Ready line is high

Rear panel

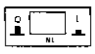


CONF. TEST:	OFF
PARITY ON/OFF:	Irrelevant
PARITY ODD/EVEN:	Irrelevant
DUPLEX:	Irrelevant
BAUD RATE:	Same as host computer/terminal
MODEM/HARDWIRE:	MODEM (Refer to Chapter 10.)

On Line and Programmed On Mode

The plotter enters this mode from the "On Line and Programmed Off" mode, upon receipt of a PLOTTER ON instruction from the host computer or front panel. In this mode the plotter responds to device control and graphic instructions from the computer, and passes data from the terminal to the computer including "Breaks". Receipt of a "Break" from the terminal aborts any in-process plotter outputs, and returns the plotter to the "On Line and Programmed Off" mode, but plotting continues until stored buffer data is completed. Front and rear panel settings are:

Front panel


On (set to "1")

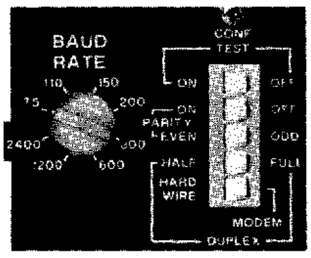
Off and lamp off

Off and lamp off

On and lamp flashing upon receipt of PLOTTER ON.

DATA SET
On steady if modems Data Set Ready line is high.

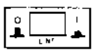
Rear panel



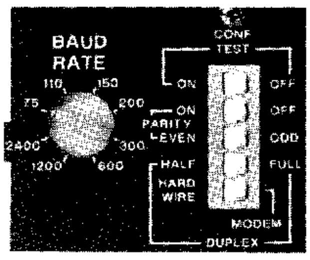
CONF. TEST:	OFF
PARITY ON/OFF:	Off for no parity On for odd or even parity
PARITY ODD/EVEN:	Same as host computer
DUPLEX:	Irrelevant unless "monitor mode" is active (refer to Chapter 10).
BAUD RATE:	Same as host computer/terminal
MODEM/HARDWIRE	MODEM (refer to Chapter 10).

Local and Programmed Off Mode

In this mode, the plotter ignores all data from the host computer and remains in a passive state awaiting a PLOTTER ON instruction from the terminal or front panel. Front and rear panel control settings are:

Front panel		On (set to "1")
	STBY	Off and lamp off
Press	LOCAL	On and lamp on steady
	ON LINE	Off and lamp off
	DATA SET	On steady, if connected to a modem and the modem's Data Set Ready line is high.

Rear panel

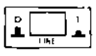


CONF. TEST:	OFF
PARITY ON/OFF:	Irrelevant
PARITY ODD/EVEN:	Irrelevant
DUPLEX:	FULL for echo return to terminal. HALF for echo suppression.
BAUD RATE:	Same as terminal
MODEM/HARDWIRE	MODEM (Refer to Chapter 10.)

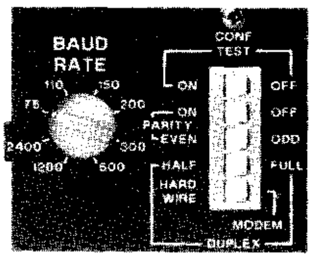
2

Local and Programmed On Mode

The plotter enters this mode from the "Local and Programmed Off" mode, upon receipt of a PLOTTER ON instruction from the terminal or front panel. In this mode, the plotter responds to device control and graphic instructions from the terminal. All data from the host computer is ignored. Front and rear panel settings are:

Front panel		On (to "1")
		Off and lamp off
		On and lamp flashing upon receipt of PLOTTER ON
		Off and lamp off
	DATA SET	On steady if connected to a modem and the modem's Data Set Ready line is high.

Rear panel



CONF. TEST:	OFF
PARITY ON/OFF:	Off for no parity. On for odd or even parity.
PARITY ODD/EVEN:	Same as terminal. Settings are relevant only for plotter-generated data output to terminal. Settings are irrelevant for data received from terminal or echoed to terminal (full duplex).
DUPLEX:	FULL for echo return to terminal. HALF for echo suppression.
BAUD RATE:	Same as terminal.
MODEM/HARDWIRE:	MODEM (Refer to Chapter 10.)

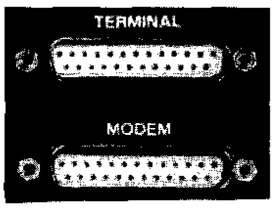
Installation/Operation With A Hard Wired Computer And Terminal

Installation

A second type system installation connects the plotter with a computer and terminal by direct cabling. The plotter is connected in series between the computer and terminal as shown in Figure 2-13. Rear-panel connections are as follows:

Terminal to

Computer to



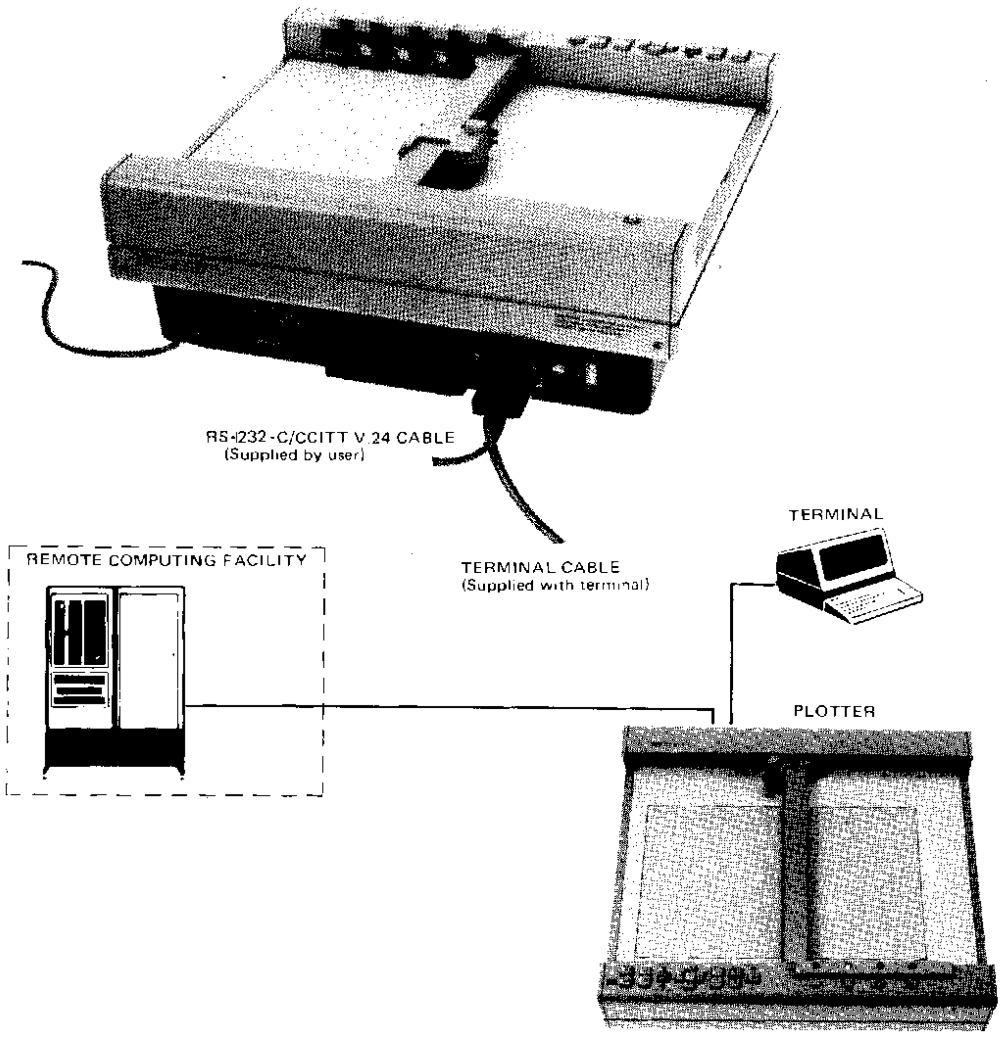


Figure 2-13. Plotter Interconnection with a Terminal and Remote Facility Using RS-232-C/CCITT V.24 Cabling

Operation

System operation in this type installation is identical to operation with a modem and terminal, except that Data Set Ready is controlled by the host computer and the MODEM/HARDWIRE switch is set to HARDWIRE. Refer to operating procedures of the following six modes in the discussion of "Installation/Operation with a Modem and Terminal:"

- **Power Off**
- **Standby**
- **On Line And Programmed Off**
- **On Line And Programmed On**
- **Local And Programmed Off**
- **Local And Programmed On**

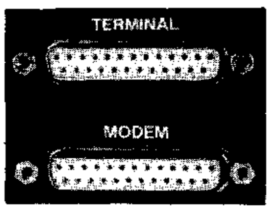
Installation/Operation With A Computer Mainframe

Installation

In this type system the plotter is adjacent and connected directly to a computer. Plotter activity is under program control of the computer; however, entry to the computer by a terminal is through a separate port rather than through the plotter. Figure 2-14 illustrates the system installation, and rear panel connections are as follows:

Not connected

Computer to



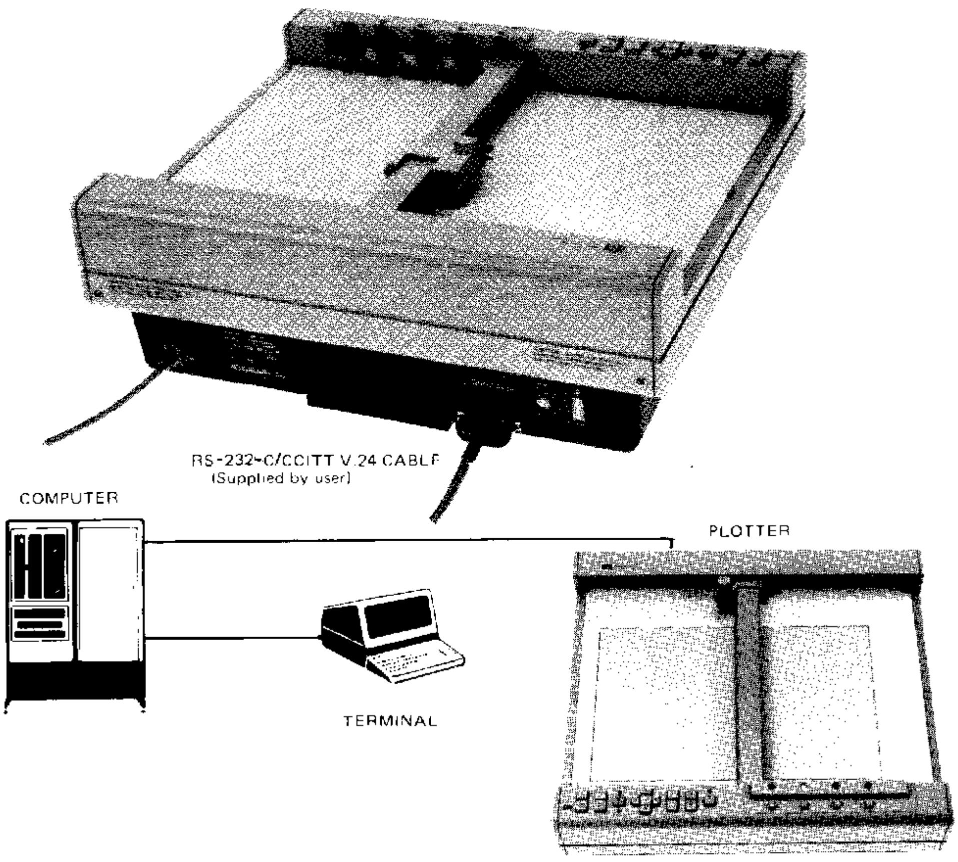


Figure 2-14. Plotter Connection With A Computer Mainframe

Operation

Operation with this type installation is confined to the three modes listed below and discussed in "Installation/Operation With A Modem And Terminal:"

- **On Line And Programmed Off**
- **On Line And Programmed On**
- **Standby**

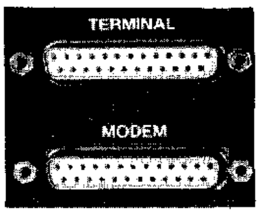
Installation/Operation With A Terminal

Installation

In this type system the plotter is adjacent and connected to a terminal. This type installation is used for off-line labeling and data point digitizing. Figure 2-15 illustrates this installation, and rear panel connections are as follows.

Terminal to

Not Connected



Operation

Operation with this type installation is confined to the three modes listed below and described in "Installation/Operation With A Modem And Terminal:"

- **Local and Programmed Off**
- **Local And Programmed On**
- **Standby**

Refer to Chapter 4 for information regarding elementary operation of the plotter from a terminal.

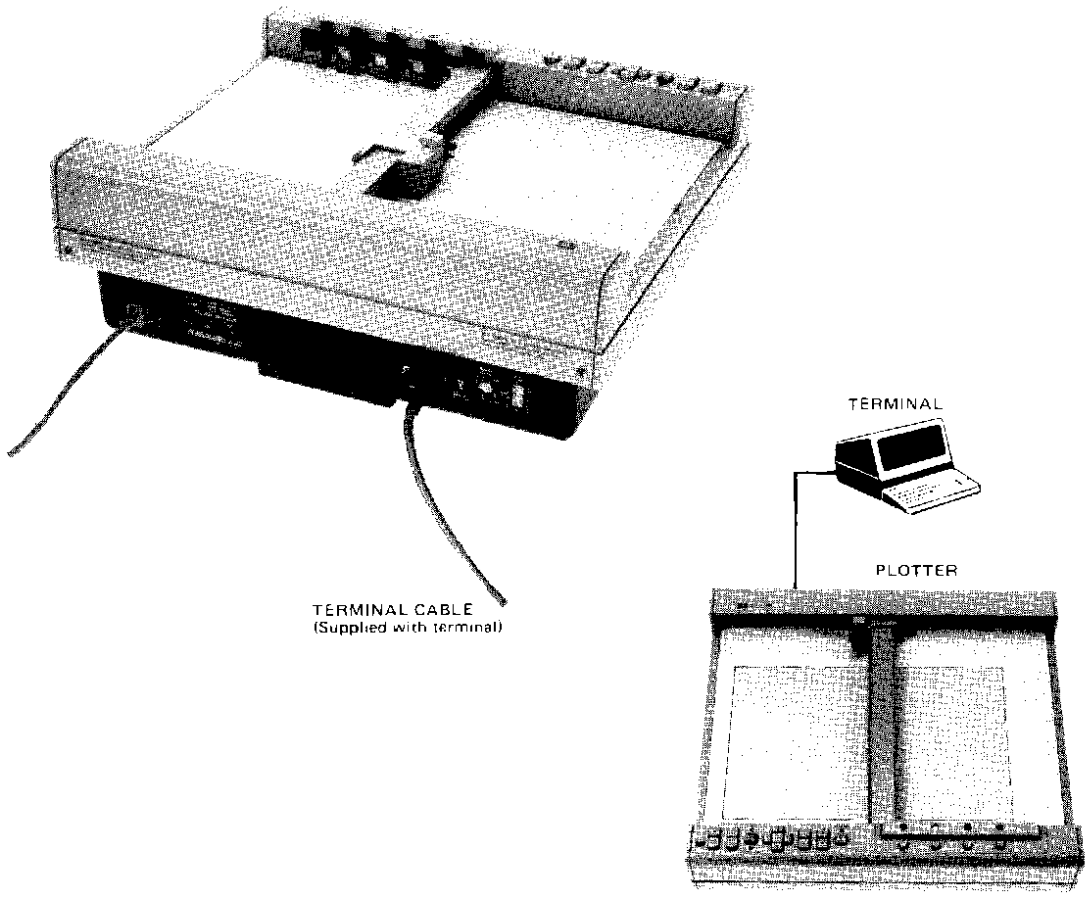


Figure 2-15. Plotter Connection With A Terminal

Chapter 3

General Programming Information

Introduction

3

This chapter contains the following discussions:

- Operating Modes
- Basic Plotter Capabilities
- Functional Operation
- Philosophy of Binary Format

Operating Modes

The plotter generally operates in series between a host computer and a terminal in six modes described herein. Physical connections of the plotter with a computer and terminal are described in Chapter 2.

Power Off

When the plotter is connected in a communication channel with a host computer and terminal, and the plotter switch is off, the computer and terminal communicate through a hardwired relay connection in the plotter as shown in Figure 3-1. The plotter responds to no instructions in this mode.

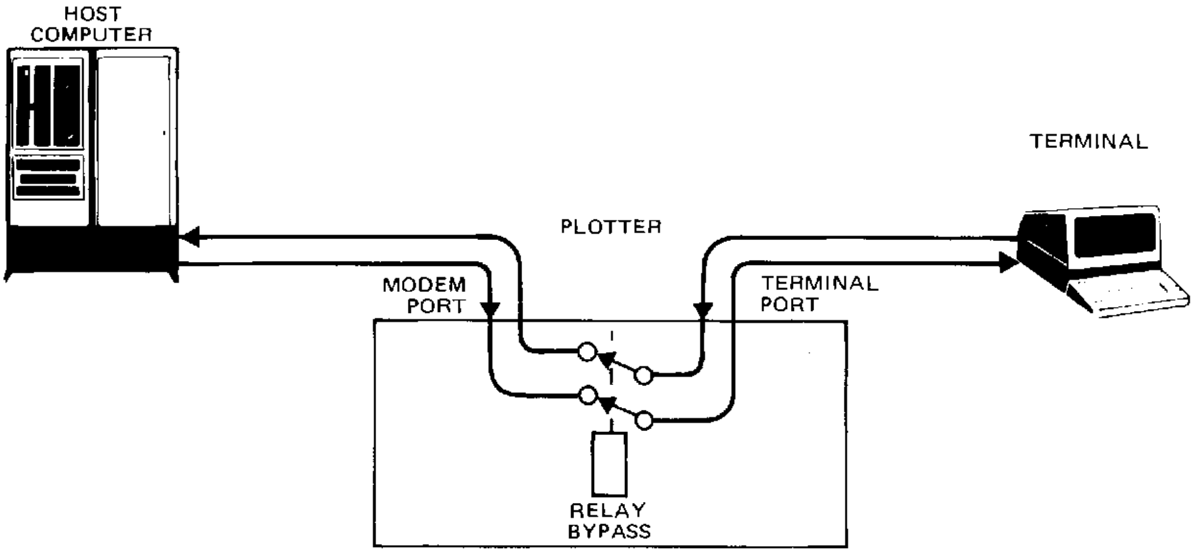


Figure 3-1. Plotter Power Off

Standby

The plotter is placed in a STANDBY mode by setting the switch on and pressing the front-panel STBY pushbutton. In this mode, the STBY pushbutton lamp is on steady and the plotter processor passes data between the host computer and terminal as shown in Figure 3-2. The plotter responds to no instructions in this mode.

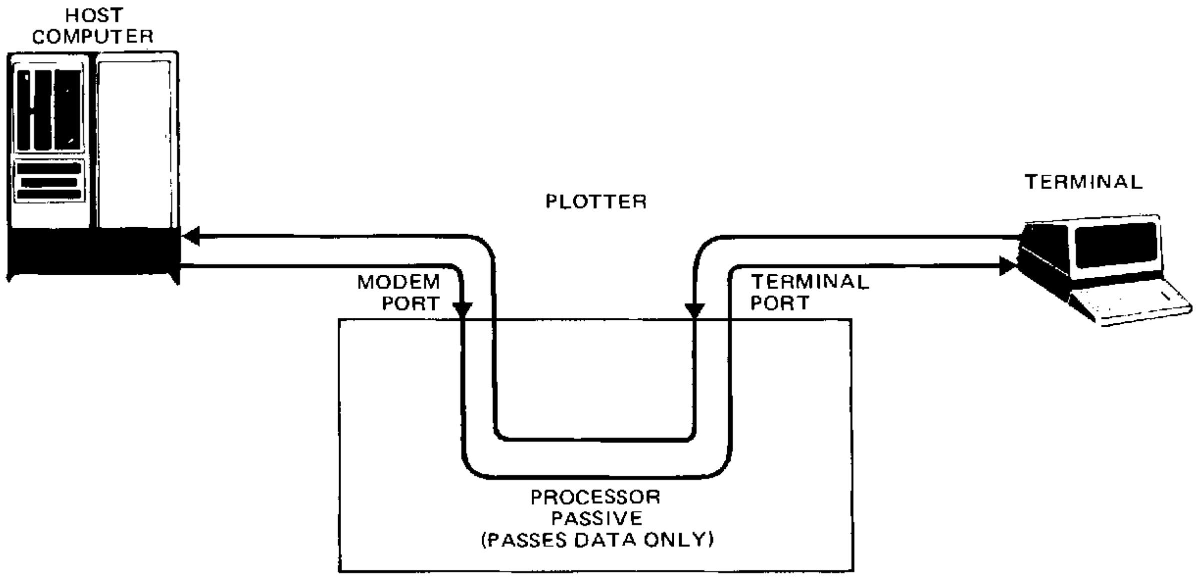


Figure 3-2. Plotter In Standby Mode

On Line-Programmed Off

The plotter is placed on line in a programmatically off state by one of the following actions:

a. Initially setting the plotter switch on.

b. Being on-line and programmatically on, and receiving a Plotter Off instruction from the computer.

c. Switching from standby to on line using the front panel and pushbuttons.

In this mode, the on-line pushbutton lamp is on steady and the processor passes data between the host computer and terminal as shown in Figure 3-3. The plotter will respond only to a Plotter On instruction.

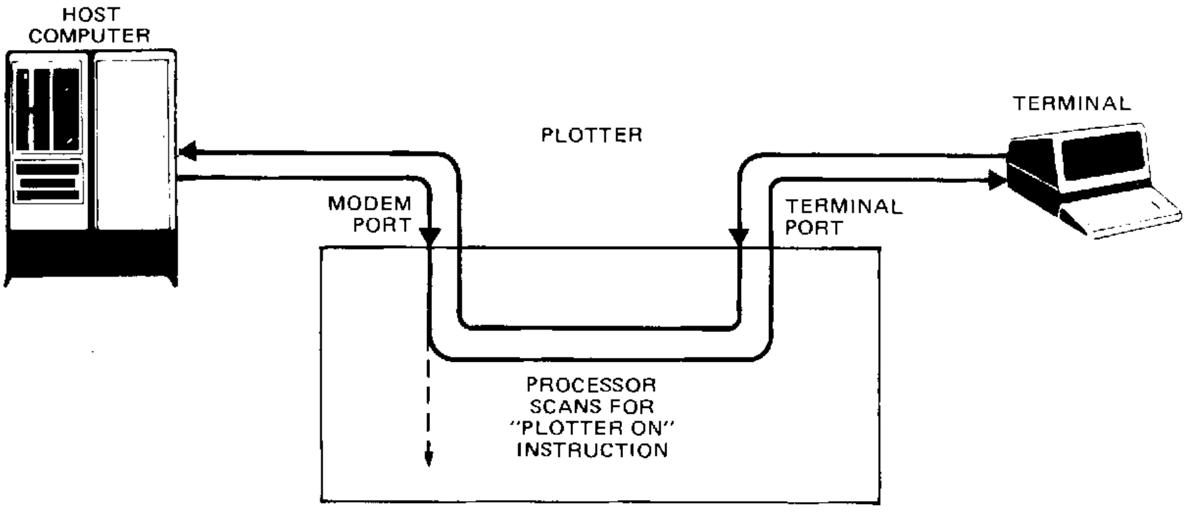


Figure 3-3. Plotter In On-Line Mode and Programmed Off

On Line-Programmed On

The plotter is placed on line and programmatically on when the plotter switch is on, the plotter is on line and programmatically off (the pushbutton lamp is on steady) and a Plotter On instruction is received from the host computer or front panel. When this mode is established, the ON LINE lamp starts flashing and the plotter operates in response to instructions received from the host computer as shown in Figure 3-4.

The plotter also provides the following outputs when the computer requests the information:

a. Plotter identification
b. Status
c. Buffer size
d. Buffer space
e. Current graphic limits
f. Current pen position
g. Error identification
h. Digitized point.

The communication channel from the terminal to the host computer through the plotter is maintained to provide operator entry into the computer. The communication channel from the plotter terminal port to the terminal is used in this mode of operation only if "Monitor Mode" is active. Refer to Chapter 8 and 10 for a description of "Monitor Mode."

The plotter processor monitors the communication channel from the terminal to the computer for a terminal-generated BREAK signal (a series of space bits). This BREAK signal causes the plotter to return to the on-line, programmatically-off condition shown in Figure 3-3. Any in-process plotter outputs are aborted, but plotting continues until stored buffer data is completed. A new Plotter On instruction from the computer or front panel is required to resume plotting operations.

NOTE

Pressing the [STBY] pushbutton will empty all graphics data from the buffer.

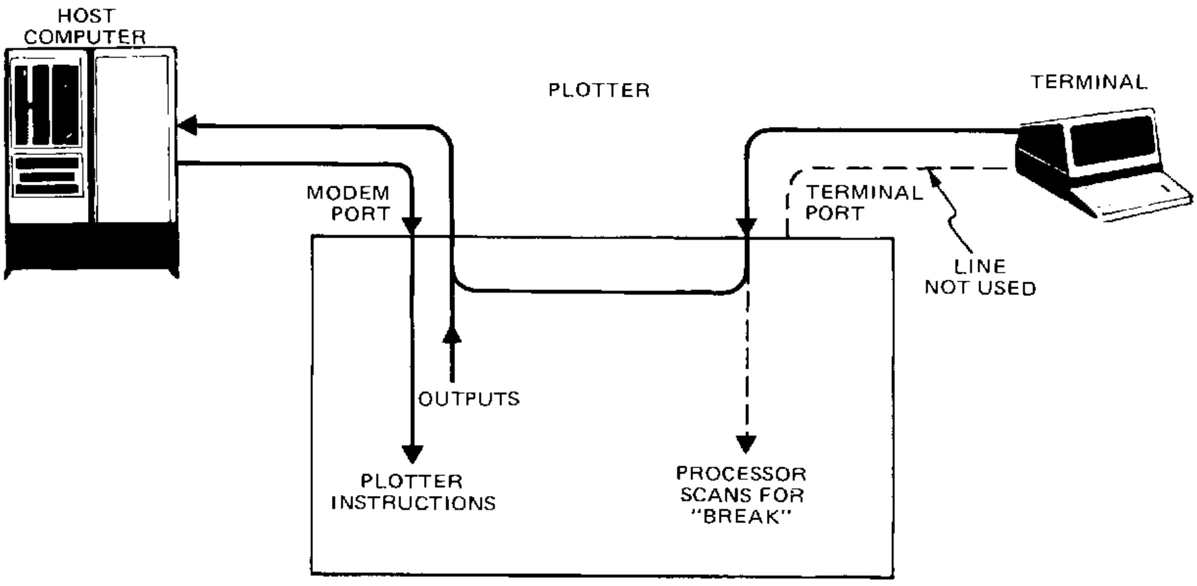


Figure 3-4. Plotter In On-Line Mode and Programmed On

Local-Programmed Off

The plotter is placed in the local mode and programmatically off when the switch is turned on and the front panel pushbutton is pressed to cycle the lamp on steady. In this mode, the processor scans for a Plotter On instruction from the terminal or front panel as shown in Figure 3-5. The lines between the host computer and the plotter modem port are not used and any data from the computer is ignored. The rear-panel switch is operational in this mode of operation. When the switch is set to FULL DUPLEX, the data received from the terminal is echoed (retransmitted) back to the terminal. In HALF DUPLEX, this echo is suppressed and the line from the plotter terminal port to the terminal is not used.

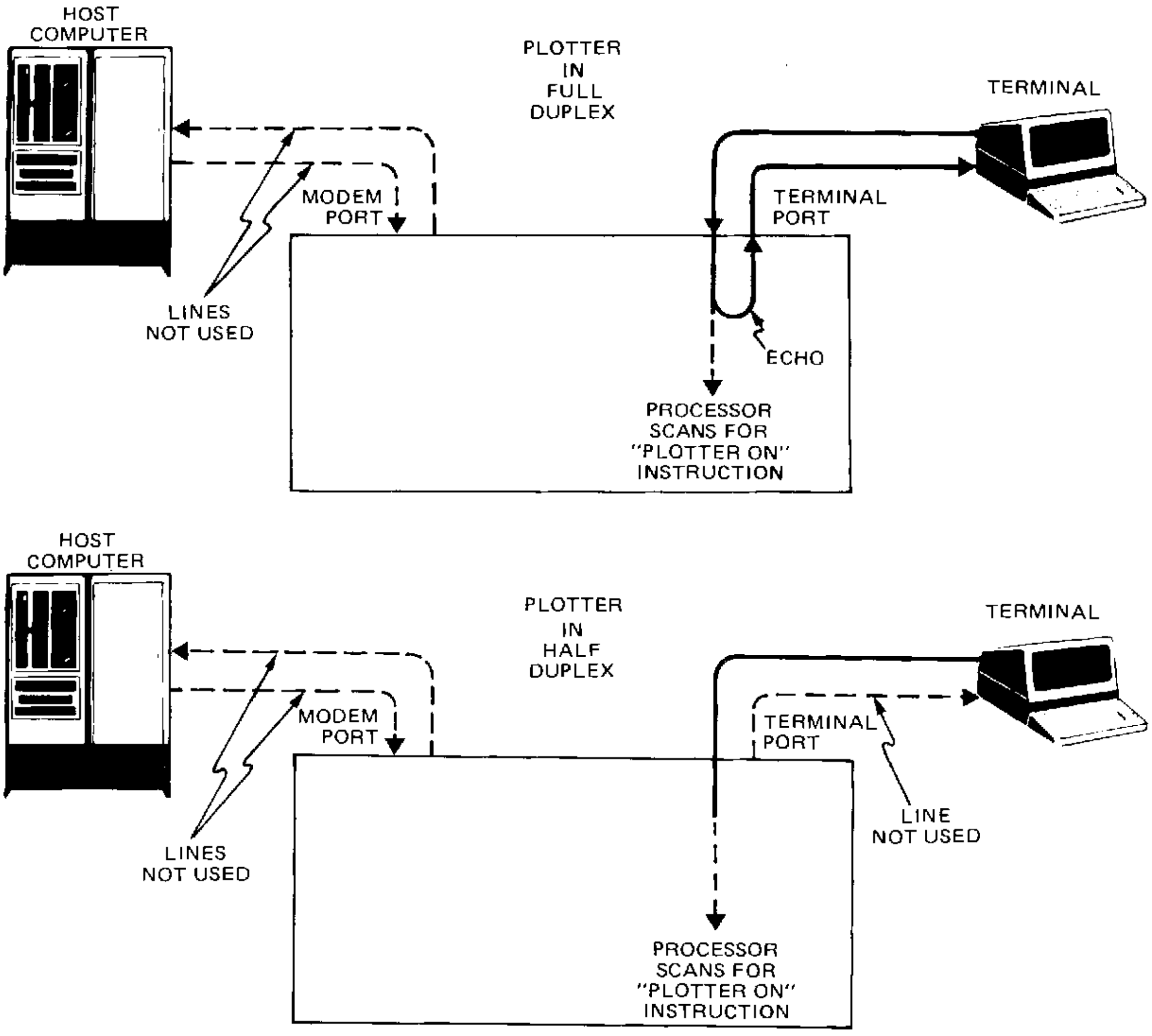


Figure 3-5. Plotter In Local Mode and Programmed Off

Local-Programmed On

The plotter is placed in local mode and programmed on when the switch is on, the pushbutton has been operated (the pushbutton lamp is on steady) and a Plotter On instruction is received from the terminal or by again pressing the pushbutton. In this mode, the LOCAL pushbutton lamp is flashing and the plotter operates in response to instructions from the terminal as shown in Figure 3-6. The plotter also provides the same outputs, when requested by the terminal, as provided in the "On Line – Programmed On" mode. The communication channels between the host computer and plotter modem port are not used and any data from the computer is ignored. The rear-panel switch is also operational in this mode. In FULL DUPLEX the terminal input is echoed back to the terminal, and in HALF DUPLEX the echo is suppressed.

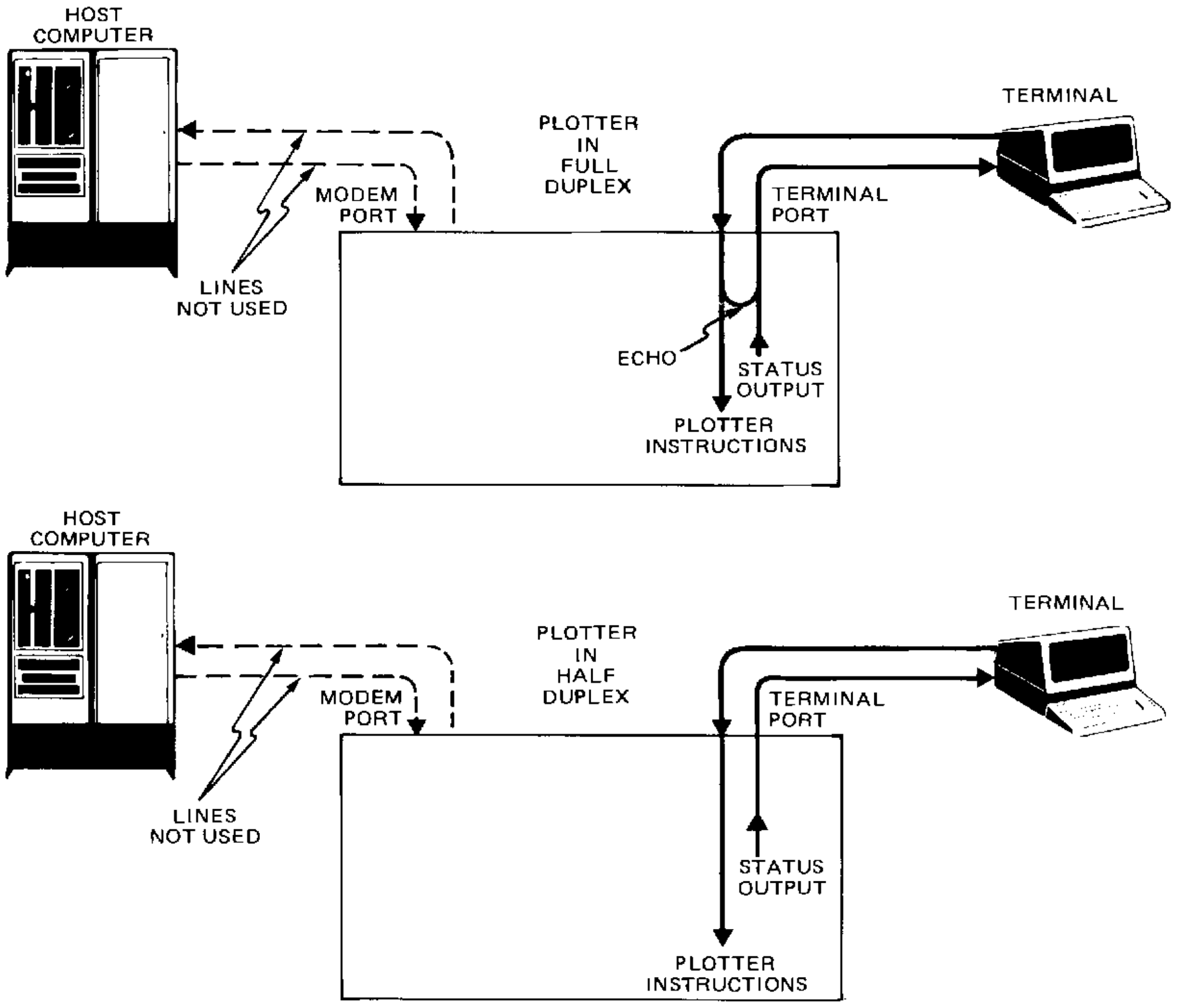


Figure 3-6. Plotter In Local Mode and Programmed On

Basic Plotter Capabilities

The plotter performs a variety of graphic and control functions in response to instructions received at the modem port or the terminal port. Some of the functions can also be initiated manually, at the plotter front panel. This section introduces some of these functions and the plotter capabilities which support them.

Unit Systems

The plotter employs the two unit systems described below:

Machine Unit System. Machine Units are fixed at one unit = .025 millimetre in both the X- and Y-directions, and are referenced to the lower left corner of the platen. The machine unit system divides the physical plotting area bounded by the mechanical limits into a fixed, square-grid network.

Plotter Unit System. The plotter unit system divides the area bounded by the graphic limits into a logical grid network. Plotter Units are of programmable size, may be defined differently in the X- and Y-directions, and are referenced to the currently-specified lower left graphic limit. The parameters of plotting instructions express plotting coordinates and linear dimensions in plotter units.

Altering Plot Size And Location

The dimensions and location of the graphic limits can be defined by plotter instruction, or set by plotter front panel controls. Since the plotter unit system is referenced to the graphic limits, this means that a plot can be drawn in any desired size and location on the platen, without altering the numeric values expressed in the parameters of plotting instructions.

Absolute And Incremental Plotting

Every individual pen movement performed by the plotter is generated as a straight-line vector from the current pen location to a specific plotter-unit coordinate location ("absolute" coordinates), or to a coordinate location relative to the current pen position ("incremental" coordinates).

Clipping

Except for pen-selection and initialize operations, all pen movements performed in response to plotter instructions are restricted by the graphic limits. The pen's **logical** position, which is maintained by plotter firmware, may lie outside the graphic limits. Its **physical** position, however, follows its logical position only while the latter is on or within the graphic limits.

Vectors which start or end outside the graphic limits are "clipped" at the affected boundary; vectors which lie entirely outside the limits produce no pen movement.

Line-Drawing

The plotter performs individual line-drawing (pen lowered) and move (pen raised) operations in response to appropriate plotter instructions. The instructions may designate either "absolute" or incremental vectors.

Arcs And Circles

An arc (or circle, which is treated as an arc of 360 degrees) is actually drawn as a series of straight chords which approximate the arc. The angle, radius and orientation of the arc are specified by a single plotter instruction. The plotter internally generates and executes the required series of chords as **incremental vectors**.

Labels

The plotter draws numerals, symbols and text characters, using any of six program-selectable character sets. Character size, spacing and slant are also programmable. The ASCII character codes are transmitted to the plotter, which internally generates and executes the **incremental vectors** necessary to produce the desired graphic characters and displacements.

Pen Selection (Multiple Colors)

Any of four pens can be selected for drawing. Selection is initiated by plotter instruction or front panel controls. The plotter internally generates all the movements of the pen holder and pen arm necessary to accomplish the specified pen-change, and to return to the current graphic position.

Dash Lines

As an alternative to solid lines, the user can programmatically define dash-line patterns consisting of dots, dashes and spaces. The plotter uses the currently-invoked pattern for drawing lines, arcs and circles. If desired, the plotter dynamically adjusts the pattern length so that no drawn vector contains a partial pattern.

Macro Instructions (Macros)

The user can programmatically define plotter instruction sequences, cause them to be stored in the plotter, and recall them for execution at a later time. This macro instruction capability provides convenience and efficiency in drawing user-defined symbols and figures, storing dash-line pattern definitions, and other repetitive graphic operations. "Macros" can also be called from an optional ROM module for special applications.

Rotation

Rotation of **incremental** vectors (including labels, arcs and circles, which are incrementally-produced) can be invoked by plotter instruction. While rotation is invoked, each incremental vector is rotated about its point of origin, either through a specified number of degrees, or to the angle of the last vector generated by the plotter.

Device Control And I/O Control

The plotter responds to various control instructions by performing requested actions and outputting requested information, such as:

a. Set plotter into programmed-on or -off state (refer to "Operating Modes" in this chapter).

b. Output digitized pen position.

c. Output plotter status information.

d. Reset errors, and output error identification and error tally.

e. Output buffer size or available buffer space.

f. Establish relevant conditions for output (e.g., turn-around delay, trigger characters).

Functional Operation

The functional configuration of the plotter's firmware and hardware is presented in Figure 3-7, and the actions performed by its principal components are described below.

Communications Interface

- Implements the EIA RS-232-C or CCITT V.24 control-line protocol.
- Routes data to and from the modem, the terminal, and the plotter I/O firmware, according to the operating mode. (Refer to "Operating Modes" in this chapter.)
- Converts received data from bit-serial format to the bit-parallel, byte-serial format, for use by the plotter I/O firmware.
- Converts output data from bit-parallel, byte-serial format to the bit-serial format required by the communication channel.
- Performs parity-checking and parity generation on I/O data.

Pre-Scanner

- Routes Device Control Instructions to Device Controller, for immediate processing.
- Routes Graphic Instructions (including their parameters, and label strings) to the Buffer, via the Pre-buffer, for serial processing.

Device Controller

- Interrogates the Graphics Processor and Buffer for status and other information, as requested by Device Control Instructions; e.g., plotter status, error status, buffer size or available space, digitizing information, current graphic limits.
- Sends requested output information to the Communications Interface, subject to relevant conditions for output (e.g., turn-around delay, trigger characters).
- Accepts, stores, and implements specified conditions for output (e.g., handshake mode specifications).

Pre-Buffer

- Buffers incoming graphic instructions, to allow the main Buffer to be "closed" temporarily, while the Buffer's dynamic boundary is moved during definition of macros.

Buffer (part of RAM)

- Holds graphic instructions received from the Pre-Scanner and Pre-Buffer, for serial processing on a First In/First Out (FIFO) basis.

- Transfers defined macros into Macro Storage.

- Occupies available RAM storage space not otherwise required for system variables and Macro Storage.

- Reports total size and/or current available space to the Device Controller, upon request.

Macro Storage (part of RAM)

- Holds specially-defined sequences of graphic instructions (macros).

- Dynamically expands and contracts as macros are added and deleted.

Macro ROM Module (Pluggable)

- Provides access to factory-assembled macros (custom feature).

Parser (Code Analyzer)

- Reads graphic instructions serially from the Buffer, or from Macro Storage or Macro ROM, as required.

- Verifies, interprets and decodes the instruction codes and parameter data.

- Passes the decoded information to the Graphics Processor.

Graphics Processor

- During initialization, establishes default values for system variables.
- Accepts signals from the front control panel pushbuttons and pen-stable sensing switches.
- Performs rotation, clipping and dash-line algorithms.
- Generates plotting information for the implied vectors of arcs and labels.
- Prepares plotting information for the Vector Generator; e.g., converts plotter-unit data to machine-unit data.
- Drives the front panel indicators.

Vector Generator

- Converts plotting data received from the Graphics Processor into appropriate electronic signals to the X and Y motor drivers and the pen lift solenoid driver.

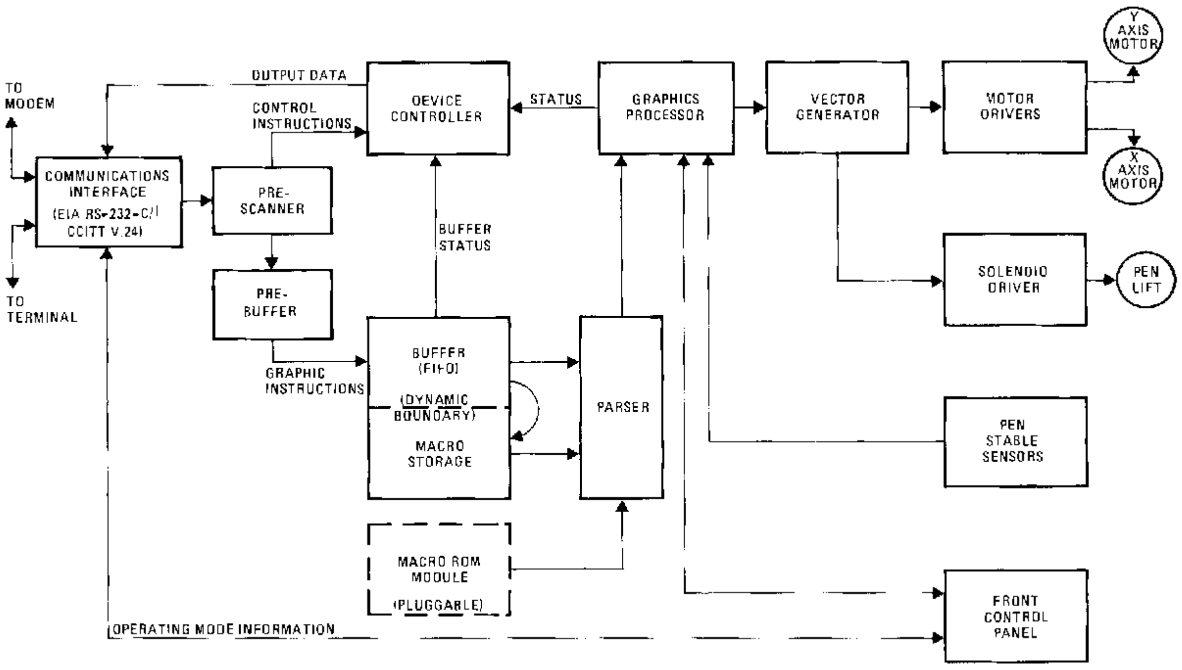


Figure 3-7. Functional Block Diagram of Plotter Hardware and Firmware

Philosophy Of Binary Format

Purpose

The binary format, herein discussed, refers to the scheme of assigning instruction codes and encoding numeric graphic parameters into binary codes. The binary format is designed to produce optimum code compaction, with the following objectives and features:

a. minimize the volume of Input/Output traffic over the communication channel;

b. optimize utilization of available buffer capacity;

c. permit Graphic Instructions and their parameters to be of variable length, without separator characters and with minimal use of special delimiters;

d. provide a means of identifying the functional significance of each byte of data extracted from the plotter's data buffer, as part of the "parsing" process.

Numeric Graphic Parameters

There are five basic binary-encoded formats for numeric graphic parameters, each designed to efficiently represent a specific class of numeric data. These are as follows:

- Single-Byte Number (SBN format)
- Multiple-Byte Number (MBN format)
- Multiple-Byte Pair of Numbers (MBP format)
- Pair of Multiple-Byte Numbers (PMB format)
- Multiple-Byte Angle (MBA format).

Appendix B, "Binary Coding Table", presents the structures, value ranges and lengths associated with each of the five types. Appendix D, the ASCII Code Table, shows plotter usage of ASCII codes. Chapter 9 contains the detailed encoding processes. Some brief examples follow.

Single Byte Number (SBN Format). This parameter expresses positive integers in the range of 0 to 63, and is always one byte in length. Pen velocity, arc tolerance, pen select and macro instructions numbers are expressed in this format.

Example: Maximum pen velocity = 27 cm per second.

Decimal Numeric Value	Binary Numeric Value	Appropriate SBN Structure	Encoded SBN Value	Equivalent ASCII Character
27	011011	CNNNNNN	1011011	[

Multiple Byte Number (MBN Format). This parameter expresses positive integers in the range of 0 to 32767. It may be from one to three bytes in length, depending on the magnitude of the current data value, and is used to express linear dimensions.

Examples: Length of an arc's radius = 4 plotter units, or 112 plotter units.

Decimal Numeric Value	Binary Numeric Value	Appropriate MBN Structure	Encoded MBN Value	Equivalent ASCII Character(s)
4	0100	110NNNN	110 0100	d
112	0001 110000	110NNNN	110 0001	a
		CNNNNNN	0 110000	0

Multiple Byte Pair of Numbers (MBP Format). This parameter expresses a pair of positive integers, and may be from one to five bytes in length, depending on the magnitude of the larger of the two integers. It is used to express absolute X,Y coordinates, the height and width of label characters, and other pairs of related values.

Example: Absolute X,Y coordinates = 100, 100 (plotter units).

Decimal Numeric Values	Binary Numeric Values	Appropriate MBP Structure	Encoded MBP Value	Equivalent ASCII Characters
		110XXXX	110 0110	f
X = 100	0110 0100			
		CXXXXYY	1 0100 01	Q
Y = 100	01 100100	CYYYYYY	0 100100	$

Pair of Multiple Byte Numbers (PMB Format). This parameter expresses a pair of integers, positive or negative, and has two separately-encoded components. Each component represents one of the two integer values, and may be from one to three bytes in length, depending on the magnitude of the corresponding value. Incremental X,Y coordinates are expressed in this format.

Example: Incremental X,Y coordinates = 100, -2000 (plotter units).

Decimal Numeric Values	Binary Numeric Values	Appropriate PMB Structure	Encoded PMB Values	Equivalent ASCII Characters
		10XXXXX	10 00011	C
X = 100	00011 00100			
		10XXXXX	10 00100	D
		01YYYYY	01 11110	>
Y = -2000	11110 00001 10000	01YYYYY	01 00001	!
	(2's complement form)	01YYYYY	01 10000	Ø

Multiple Byte Angle (MBA Format). This parameter expresses the size of an angle, in degrees, from 0.0 to 359.995. It may be from one to three bytes in length, depending on the magnitude and resolution of the value of the angle.

Example: Starting angle of an arc = 78.75 degrees.

Decimal Numeric Value	Angle Increment Values	Appropriate MBA Structure	Encoded MBA Value	Equivalent ASCII Characters
78.75	45.0	110AAAA	1100011	c
	22.5			
	11.25	CAAAAAA	0100000	SPACE

Data Differentiation

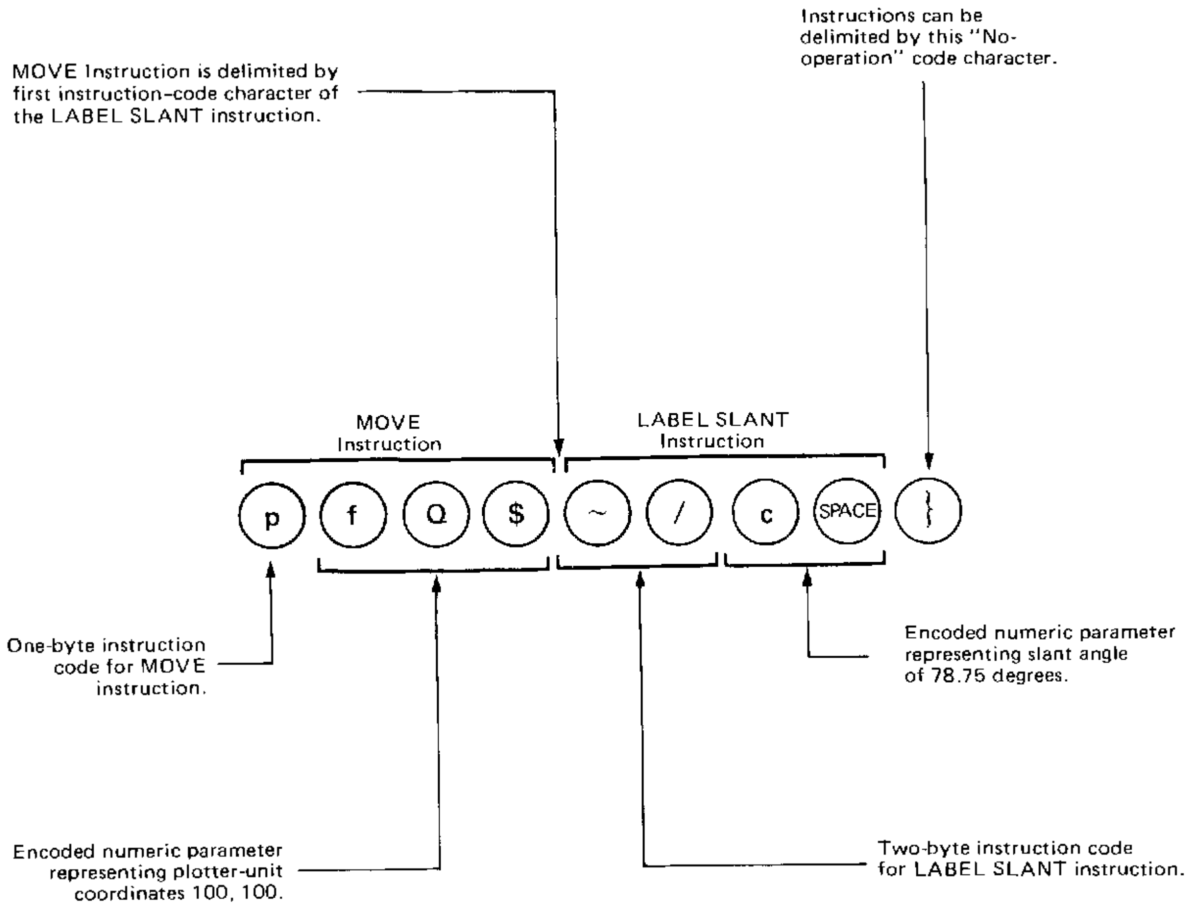
The encoded numeric parameter formats and the assignment of instruction codes follow a scheme by which : a) Device Control Instructions are intercepted and routed to the Device Controller, while Graphic Instructions are passed to the Buffer; and b) Graphic Instruction codes and parameters are uniquely identified by the Parser. This scheme is outlined below.

Functional Significance			Decimal Equivalent
Device Control Instruction Codes	First Byte	ESC	27
	Second Byte	.	46
	Third Byte		40-41, 64-79
Graphic Instruction Codes	First Order (most often used)		112-125
	Second Order: First Byte	~	126
	Second Byte		35-47, 80-95
	No-Op (Instruction delimiter)	}	125
Numeric Graphic Parameters	MBN, MBP and MBA: First Byte		96-111
	Second Byte (& up)		32-95
	PMB Format: X-components		64-95
	Y-components		32-63
	SBN Format		32-95

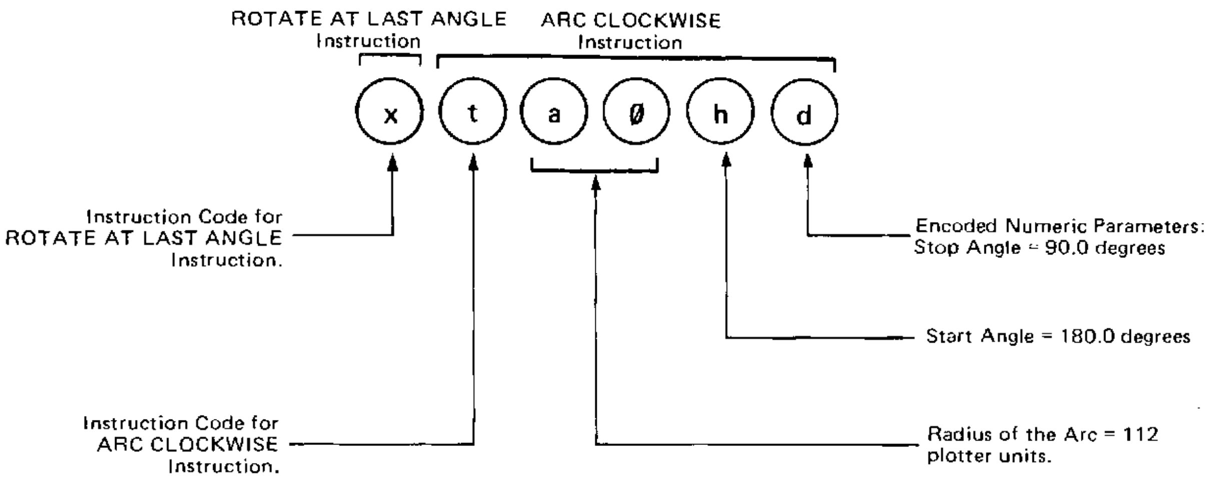
Format Of Graphic Instructions

In general, Graphic Instructions consist of a one- or two-character instruction code, and one or more variable-length, optional parameters. Graphic Instructions are delimited by the next instruction code; (i.e., recognition of an instruction code signifies the end of the previous graphic instruction). Execution of a Graphic Instruction does not normally occur until it is delimited, either by the next instruction code or by a No-operation (NOP) instruction.

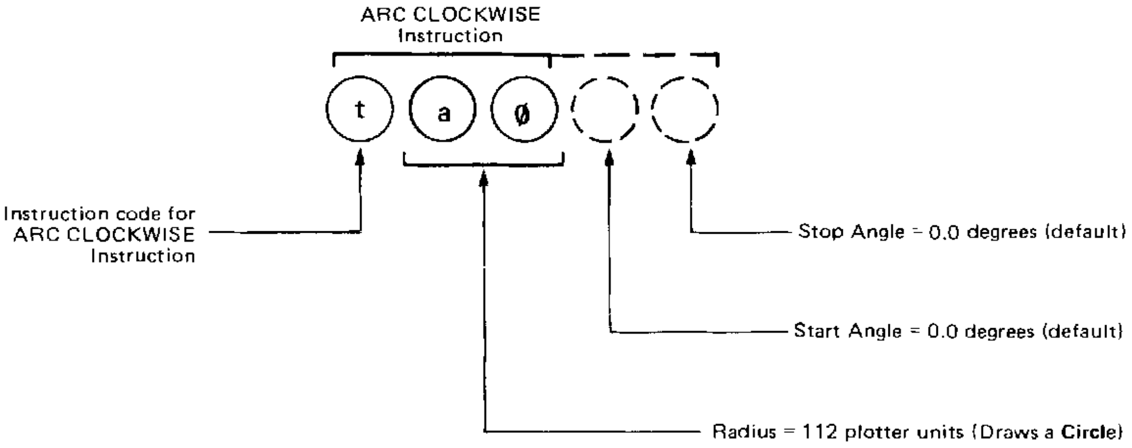
The ASCII characters, and their significance, of two typical Graphic Instructions are presented below.



Some instructions have no associated parameters while others may have several, as illustrated below.



In some cases, graphic instructions may be encoded with some or all of their parameters omitted, and the plotter assumes default or previously-specified values. The following encoded instruction illustrates this.



Chapter 4
Basic Programming Functions

Introduction

This chapter contains instructions for:

- Plotter On
- Plotter Off
- Selecting a Pen
- Setting Graphic Limits
- Setting Grid Size
- Move and Draw
- Incremental Move and Draw

Plotter On

Procedure	Set plotter for ON LINE or LOCAL. Selected lamp goes on steady.	
	Send ESC . (	PLOTTER ON instruction
Result	ON LINE or LOCAL lamp starts blinking.	

When ON LINE, the plotter stops passing data from the host computer through to the terminal, and interprets all subsequent incoming data from the computer as plotter instructions. When in LOCAL, plotter interprets incoming data from the terminal as plotter instructions.

NOTE

All Device Control Instructions start with the ESC . sequence, and are processed as soon as they are received by the plotter. They are not stored in the plotter's graphic data buffer.

Plotter Off

Procedure	Send ESC .)	PLOTTER OFF instruction
Result	ON LINE or LOCAL lamp stops blinking	

When ON LINE, the plotter resumes passing data from the host computer through to the terminal, while scanning for a PLOTTER ON instruction. When in LOCAL, the plotter scans for a PLOTTER ON instruction from the terminal.

Selecting A Pen

Procedure Install pens in the four stalls.
Send PLOTTER ON instruction.

Send (V)	PEN SELECT instruction
(A)	Pen number = 1 (SBN format)

Result Pen holder goes to the "sensing" stall to the right of the pen stable to establish whether a pen is in the holder. If a pen is in the holder, that pen is put into a vacant stall. The plotter then selects the pen from stall 1.

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Procedure

Send (V)	PEN SELECT instruction
(C)	Pen number = 3 (SBN format)

Result Plotter stores the pen in the pen holder into stall 1 and selects the pen from stall 3.

These instructions perform the same function as sequentially operating pen-select pushbuttons 1 and 3.

Setting Graphic Limits

Machine Units

Graphic limits define the desired limits of the plotting area on the platen and are specified in machine units. A machine unit is .025 mm (approximately 0.001 inch) in length, and is the smallest move the plotter can make. The largest possible plotting area is 16000 machine units wide (400 mm) in the X axis by 11400 machine units high (285 mm) in the Y axis. These dimensions are electro-mechanical limits of the plotter and are shown in Figure 2-8.

Default Values

Unless otherwise specified, the plotter assumes the following default graphic limits. These values correspond to the perimeter on HP standard grid metric sheet paper which is shown in Figure 2-8.

Lower left	XY = 520, 380 machine units
Upper right	XY = 15720, 10380 machine units

The following default graphic limits pertain only to the 7221S when roll paper is loaded (paper advance option is "on") and the ENGLISH/METRIC switch is set as indicated.

ENGLISH

Lower Left	X,Y = 520,1020 machine units
Upper Right	X,Y = 15760,11180 machine units

METRIC

Lower Left	X,Y = 520,1140 machine units
Upper Right	X,Y = 15720,11140 machine units

Unless otherwise specified, all subsequent references to default graphic limits pertain to HP standard grid metric sheet paper.

User Defined Limits

A user sets his own graphic limits using the front-panel controls, as discussed in Chapter 2, or by program control discussed herein. A new set of graphic limits permanently replaces any previously established limits. The following procedures illustrate setting graphic limits by program control.

Procedure	Send ~ W	GRAPHIC LIMITS instruction
	e 7 O (	Lower left graphic limit. X,Y = 750, 1000 machine units (MBP format).
	b : SPACE > SPACE	Upper right graphic limit. X,Y = 3000, 4000 machine units (MBP format).
	}	Terminator (NOP)

Result Establishes the graphic limits shown in Detail A, Figure 4-1. These points can be verified by pressing the LOWER LEFT and UPPER RIGHT controls on the plotter.

If no upper right parameter is included, the upper right position will "follow" a new lower-left position to maintain a position relative to the lower-left position as follows:

Procedure	Send ~ W	GRAPHIC LIMITS instruction
	c : A N H	New lower left graphic limit. X,Y = 4000, 5000 machine units (MBP format).
	}	Terminator (NOP)

Result Moves the lower left and upper right graphic limits as shown in Detail B, Figure 4-1. This can be verified by pressing the LOWER LEFT and UPPER RIGHT controls on the plotter.

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If the new upper right point is outside the mechanical limits of the plotting surface, the upper right coordinates are "clamped" to the mechanical limits. As an example:

Procedure	Send ~ W	GRAPHIC LIMIT instruction
	g K Z L (	New lower left graphic limit. X,Y = 7350, 9000 machine units (MBP format).
	}	Terminator (NOP)

Result Moves the lower left graphic limit as shown in Detail C, Figure 4-1. Note that the upper right limit moved until it reached the Y-axis mechanical limit of 11400 which then becomes the Y coordinate of the new upper right point. The front-panel controls can be used to verify these limits.

In Detail C, Figure 4-1, notice that the position of the upper right, relative to the lower left, has now changed. This new relative position is permanent, even if the lower left is moved down. As an example:

Procedure	Send ~ W	GRAPHIC LIMIT instruction
	h 2 SPACE > SPACE	New lower left graphic limit. X,Y = 9000, 4000 machine units. (MBP format).
	}	Terminator (NOP)

Result Moves the lower left graphic limit as shown in Detail D, Figure 4-1. The upper-right limit moves proportionately. The overall graphic area remains "squeezed" as shown in Detail C, Figure 4-1. The front-panel controls can be used to verify these limits.

To return the graphic limits to their default values, proceed as follows:

Procedure	Send ~ W	GRAPHIC LIMIT instruction
	}	Terminator

Result Returns the graphic limits to the default value (LL=520,380 and UR=15720,10380 as shown in Figure 4-1)

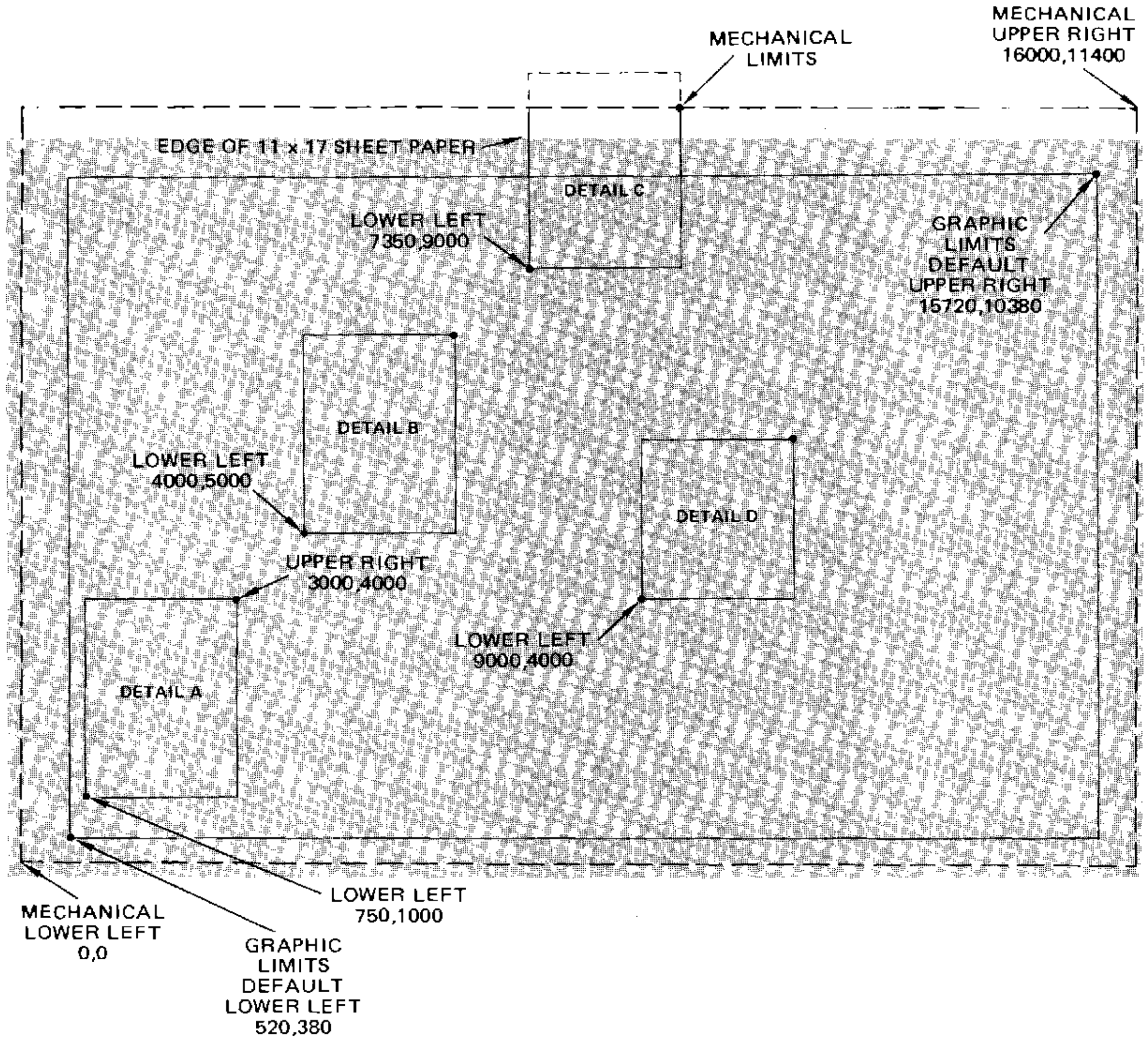

Figure 4-1. Setting Graphic Limits

Setting Grid Size

Plotter Units

Grid size establishes full-scale plotter units, which are the number of units between the point of origin of a plot (0, 0) and the full scale values of the X and Y axes (Xmax, Ymax). As an example, a grid of 5 x 7 has 5 plotter units in the X-axis and 7 units in the Y-axis as shown in Figure 4-2. The plotter units establish resolution of a plot, and affect the number of data bytes required to generate a plot. Numerical limits of 16,383 plotter units can be handled in either axis; however, the maximum plotter resolution is .025 mm even when finer resolution is specified by a user.

Default Values

If a grid size value is not specified in a plotting instruction, the plotter sets the following default grid size:

X Axis = 3040 plotter units
Y Axis = 2000 plotter units.

When both graphic limits and grid size are not specified in a plotting instruction, the 3040, 2000 grid is mapped onto the previously discussed default graphic limits.

User Defined Grids

The user sets grid size by program control. A 5 x 7 grid is set as follows:

Procedure	Send	~ S	SET GRID SIZE instruction
		b '	X max, Y max X,Y = 5 x 7 plotter units (MBP format)
		}	Terminator

Result Establishes a 5 x 7 grid within the default graphic limits as shown in Figure 4-2. Graphic positions on the plot surface include only integer coordinates in the grid system. If the pen is moved with the front-panel arrow controls to positions other than an integer coordinate, the pen will be forced to the nearest graphic position when the arrow pushbutton is released.

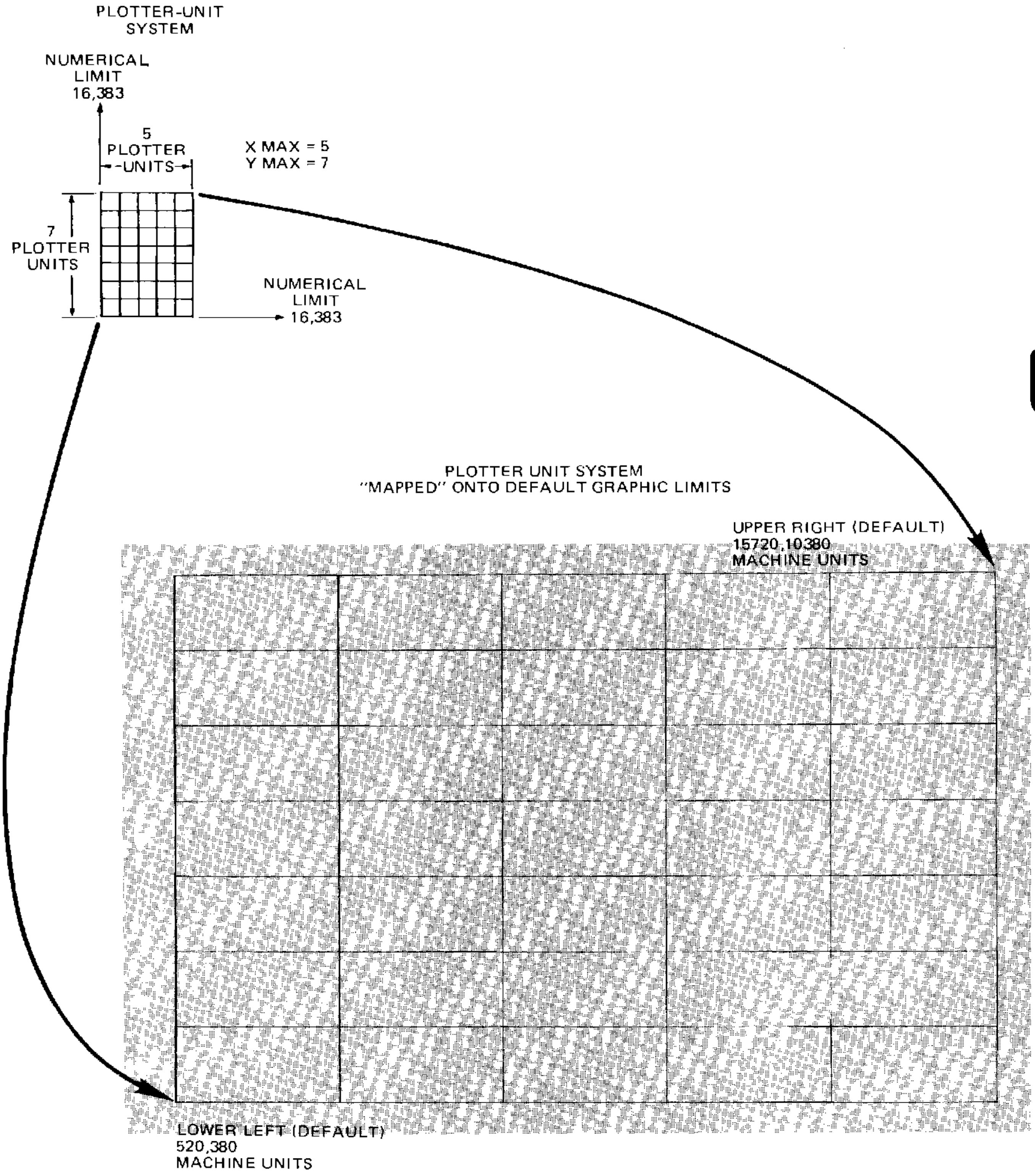

Figure 4-2. Setting a Grid Within Default Graphic Limits

To set a grid size within defined graphic limits, proceed as follows:

Procedure	Send	~ W	GRAPHIC LIMIT instruction
		e 7 O (	Lower left graphic limit. X,Y = 750, 1000 machine units (MBP format)
		e 7 @ > SPACE	Upper right graphic limit. X,Y = 6000, 4000 machine units (MBP format)
		~ S	SET GRID SIZE instruction
		b '	X max, Y max X,Y = 5 x 7 plotter units (MBP format)
		}	Terminator

Result Establishes a 5 x 7 grid within the graphic limits shown in Figure 4-3. Graphic limits can be verified by use of the LOWER LEFT and UPPER RIGHT front panel controls. Integer coordinates within the grid can be verified by pressing, then releasing ↑ ← FAST → ↓ while the pen is within the graphic limits.

A square grid system is defined when the physical distance on the plot surface corresponding to a single plotter unit is the same in both the X and Y axes. For this condition to exist, the aspect ratio of the box established by current graphic limits must equal the ratio of the grids full scale X value to full scale Y value. Instructions that include angle parameters will produce true angles only if a square grid exists. If a non-square grid exists, arcs will appear elliptical. The following example illustrates a grid of 5 x 7 established within graphic limits with the same aspect ratio (lower left = 520, 380 and upper right = 5520, 7380). Since the grid was established in the foregoing procedure, only new graphic limits must be set.

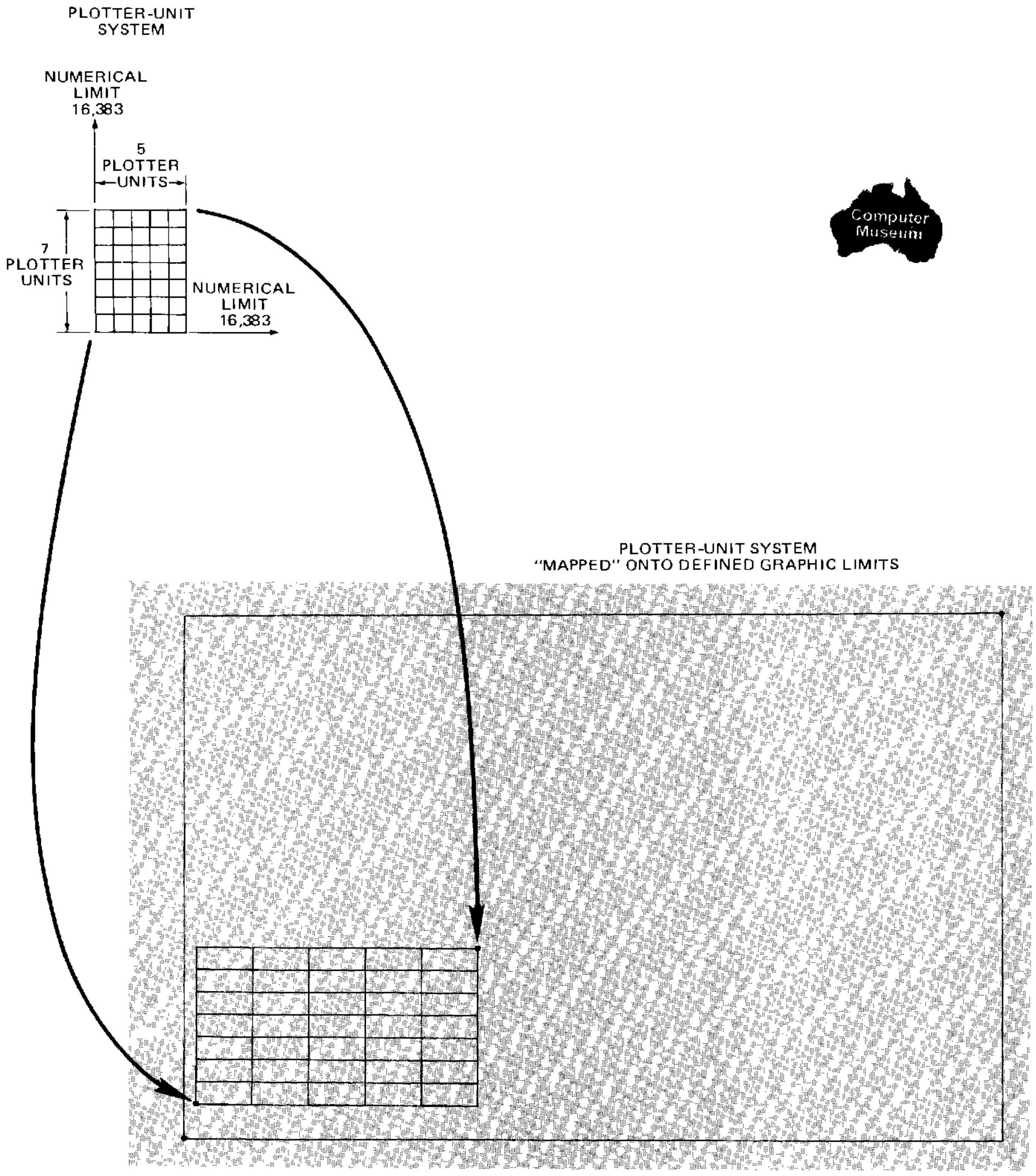

Figure 4-3. Setting a Grid Within Defined Graphic Limits

Procedure	Send ~ W	GRAPHIC LIMIT instruction
	d D E <	Lower left graphic limit. X,Y = 520, 380 machine units (MBP format)
	e Y A 3 T	Upper right graphic limit. X,Y = 5520, 7380 machine units (MBP format)
	}	Terminator

Result Establishes a 5 x 7 grid within the defined graphic limits shown in Figure 4-4. Note that each plotter unit has equal X and Y dimensions. Graphic limits can be verified by use of the LOWER LEFT and UPPER RIGHT controls. Integer coordinates within the grid can be verified by pressing, then releasing, the arrow pushbuttons while the pen is within the graphic limits.

To return the grid size and graphic limits to their default values, proceed as follows:

Procedure	Send ~ S	SET GRID SIZE instruction
	~ W	GRAPHIC LIMIT instruction
	}	Terminator

Result Both grid size and graphic limit return to their default values:

Grid size: X max, Y max = 3040, 2000 plotter units

Graphic limits: Lower left = 520, 380 machine units
Upper right = 15720, 10380 machine units.

Integer coordinates within the default grid are so close together (.125 mm) that pen movement between coordinates is not discernible.

4

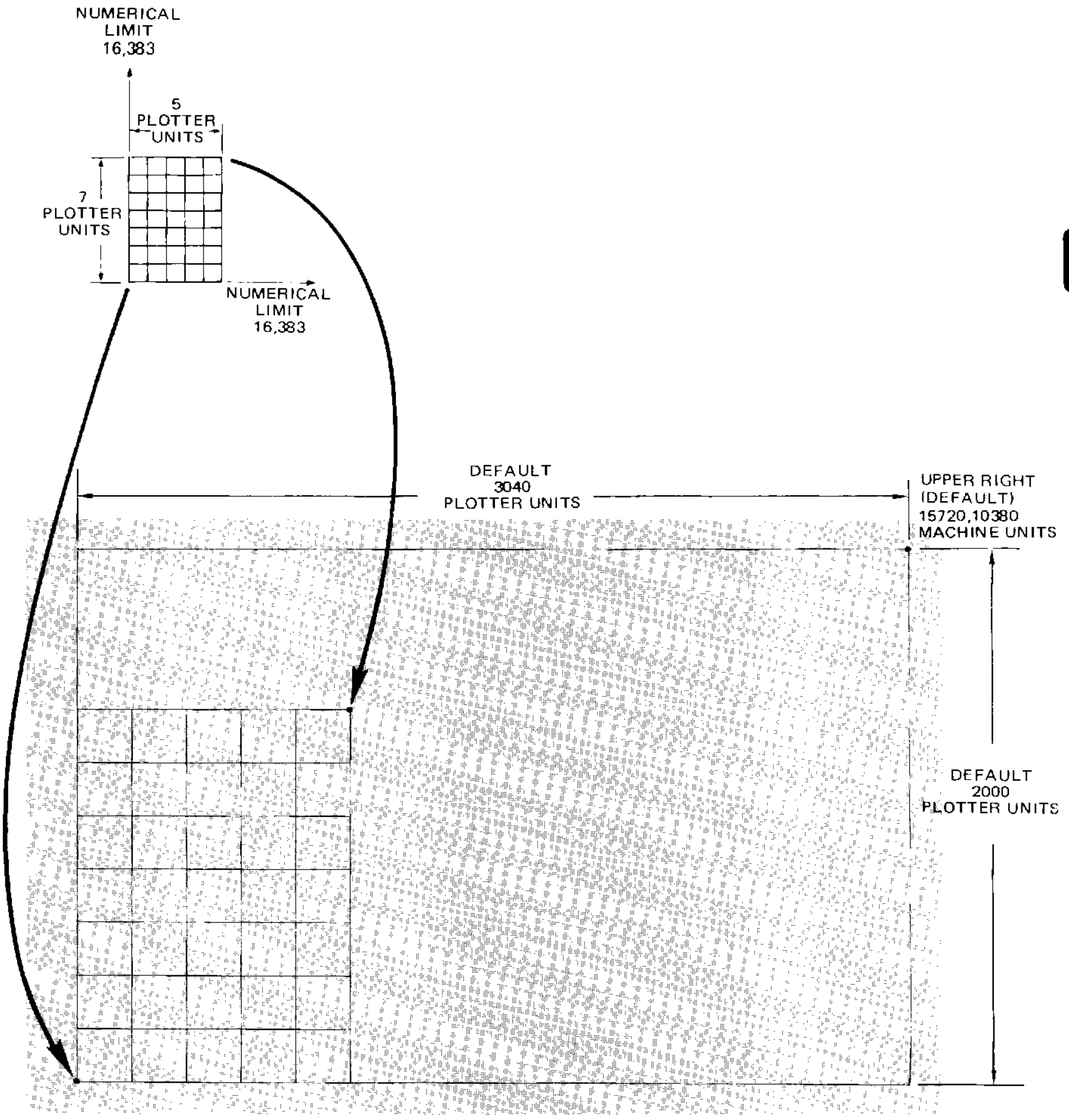

Figure 4-4. Setting a Square Grid

Move And Draw

Performing A Draw

A user performs a draw by program control. The instruction causes the pen to lower before moving to the graphic position specified by MBP (multiple byte pair) parameters. Both draw and move parameters are expressed in plotter units as shown in the following examples. The first example provides a draw from upper right to lower left (0, 0 in plotter units) with procedures as follows:

Procedure Press the plotter front-panel UPPER RIGHT pushbutton.

Send	q	DRAW instruction
	`	Lower left parameters. X,Y = 0, 0 plotter units (MBP format)
	}	Terminator

Result Pen lowers and draws a diagonal line from upper right to lower left as shown in Figure 4-5. Note that 16 seconds after reaching the lower left parameter the pen is automatically raised.

If more than one X-Y parameter is transmitted, the pen is moved to the second graphic position and all successive points in a lowered state. The following example causes a square box to be drawn. Note that the actual draw occurs when the first character of the succeeding multiple byte pair is sent.

Procedure Send	q	DRAW instruction
	` @ O (	First draw parameter to X,Y = 0, 1000 plotter units (MBP format)
	g 4 O (	Second draw parameter to X,Y = 1000, 1000 plotter units (MBP format)

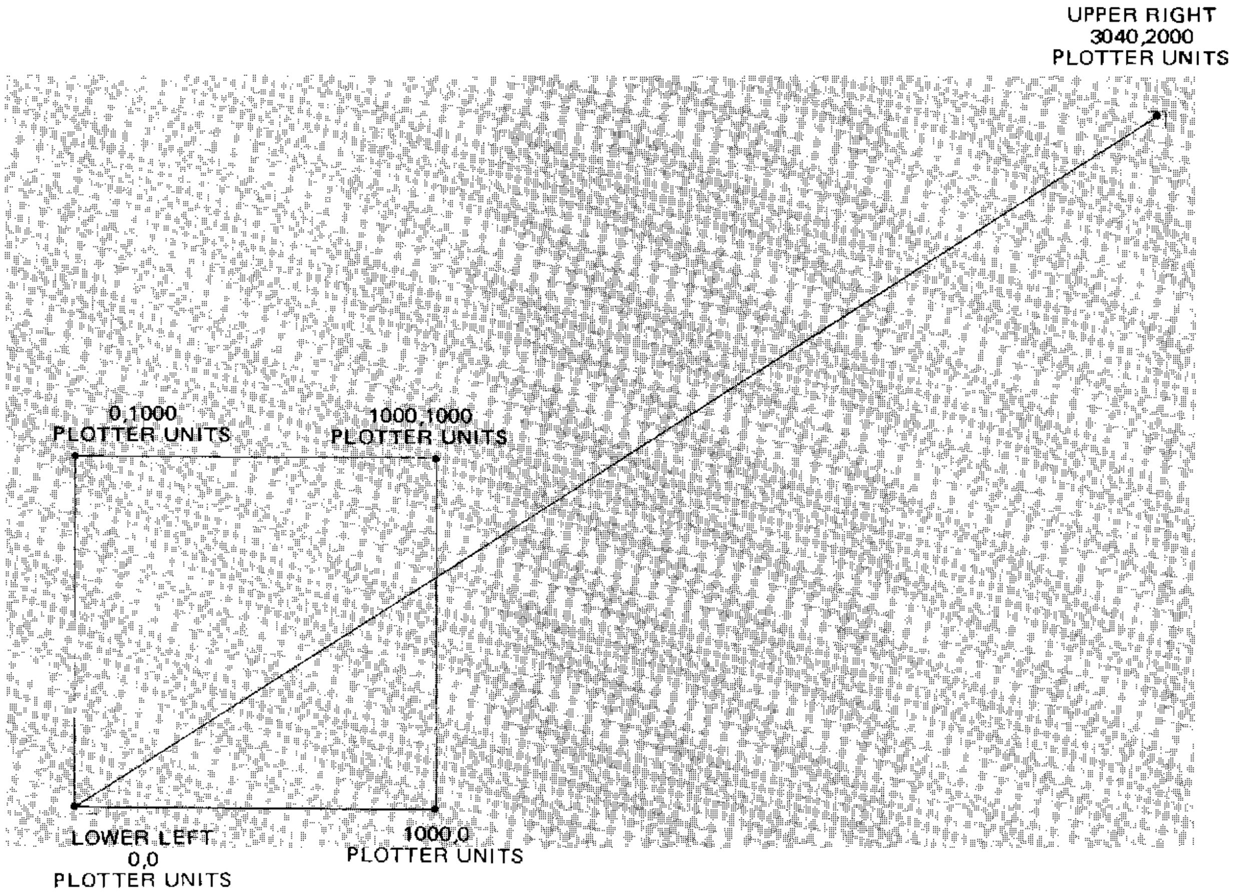

Figure 4-5. Performing a Draw

Procedure (Continued)

Send	g 4 @ @	Third draw parameter to X,Y = 1000, 0 plotter units (MBP format)
	`	Fourth draw parameter to X,Y = 0, 0 plotter units (MBP format)
	}	Terminator

Result Pen lowers and draws a box as shown in Figure 4-5. Each draw occurs when the first character of the following parameter is sent. The fourth draw occurs when the terminator is sent.

When a parameter is received that is outside specified graphic limits, the pen moves to the point where the projected draw leaves the defined graphic limits. The pen stops at this point and is raised. Subsequent parameters can be sent that are outside the limits, but the pen will not respond until a parameter is received that brings the draw back within the graphic limits. When this parameter is received, the raised pen is moved to the point where the draw re-enter the limits. The pen lowers at that point and completes the draw within limits. The following example illustrates an out-of-limit draw using default graphic limits:

Procedure Press the plotter front-panel UPPER RIGHT pushbutton

Send	q	DRAW instruction
	c : G 4	First draw parameter to X,Y = 500, 500 plotter units (MBP format)
	` > SPACE ` D	Second draw parameter to X,Y = 1000, 2500 plotter units (MBP format)
	o (@ @	Third draw parameter to X,Y = 2000, 0 plotter units (MBP format)
	}	Terminator

Result Plot is drawn as shown in Figure 4-6.

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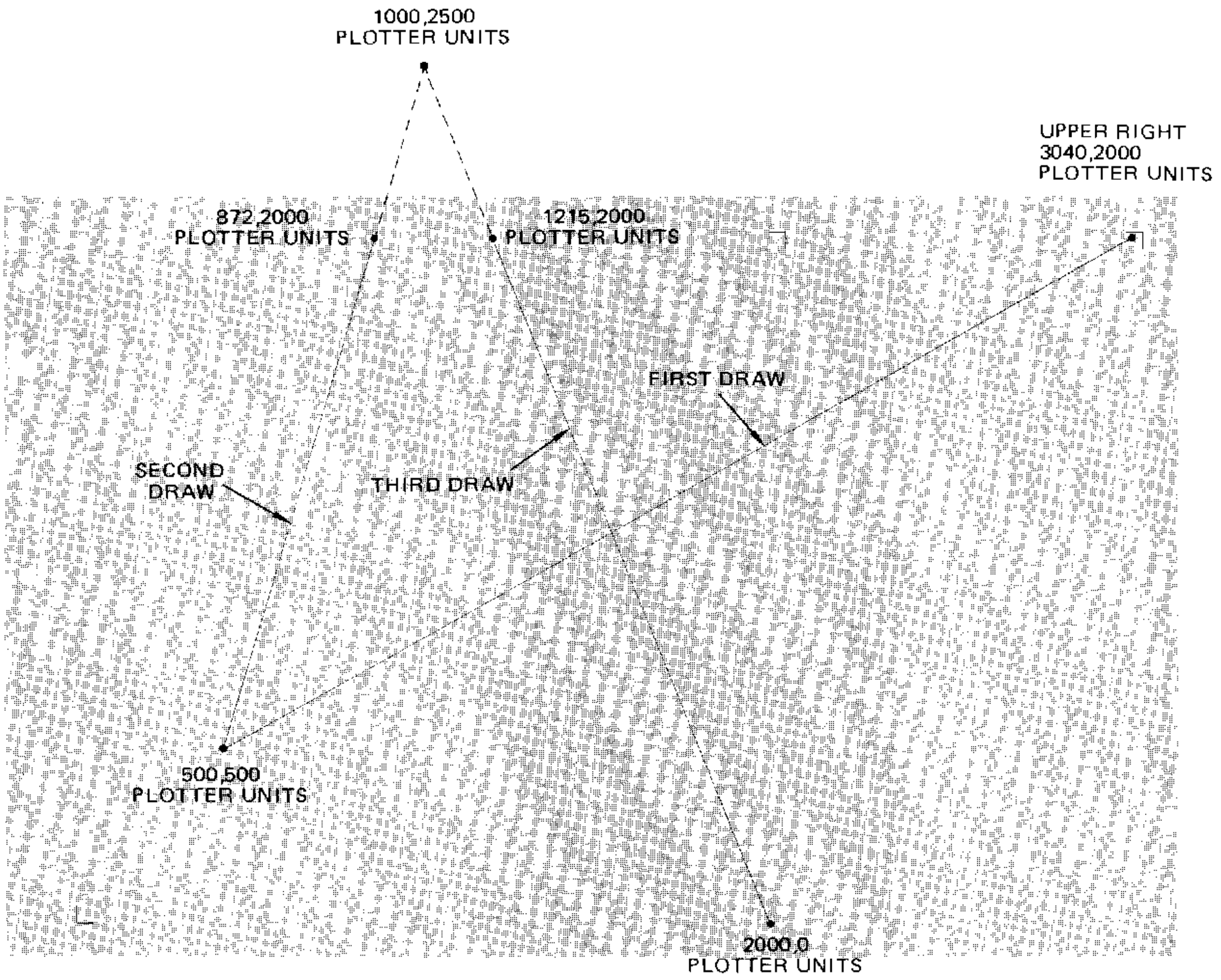


Figure 4-6. Performing an Out-of-Limits Draw

The pen can be lowered by use of the draw instruction. This function parallels use of the front-panel PEN DOWN control. Proceed as follows:

Procedure	Send	q	DRAW instruction
		}	Terminator

Result Pen lowers upon receipt of the terminator character }. Pen will automatically raise after 16 seconds if no further drawing is requested.

Performing A Move

A user performs a move by program control. The instruction raises the pen, if down, and moves it from the present location to the graphic position specified by the first multiple byte pair parameter. If the instruction has more than one multiple byte pair parameter, the pen is lowered at this point and all succeeding moves within the specified graphic limits are made with the pen down. The following example illustrates moving from upper right (3040, 2000 plotter units) to lower left (0, 0 plotter units) and drawing a box.

Procedure Press the plotter front-panel UPPER RIGHT control.

Send	p	MOVE instruction
	`	First move parameter to X,Y = 0, 0 plotter units (MBP format)
	` @ O (	Second move parameter to X,Y = 0, 1000 plotter units (MBP format)
	g 4 O (	Third move parameter to X,Y = 1000, 1000 plotter units (MBP format)
	g 4 @ @	Fourth move parameter to X,Y = 1000, 0 plotter units (MBP format)

4

Procedure (Continued)	Send `	Fifth move parameter to X,Y = 0, 0 plotter units (MBP format)
	}	Terminator
Result	Plot is drawn as shown in Figure 4-7.	

If the pen is down and the move instruction is received without parameters, the pen will raise. An example follows:

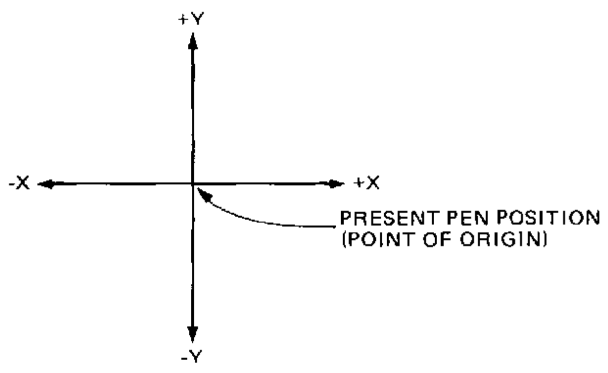
Procedure Lower the pen using the plotter front-panel PEN DOWN control.

Send p

Result The pen raises. This function parallels the use of the front-panel PEN UP control.

Incremental Move And Draw

The parameters of the incremental move and incremental draw instructions specify the X and Y incremental distances, in plotter units, that the pen is to be moved from its present position. The parameters are in the "pair of multiple byte numbers" (PMB) format. The incremental coordinates can have positive or negative values, and are referenced to a point of origin represented by the present pen position, as illustrated below.



In other respects the incremental moves and draws have the same characteristics as the move and draw instructions described earlier. In all of the following procedures the graph limits and grid sizes are assumed to be in their default values.

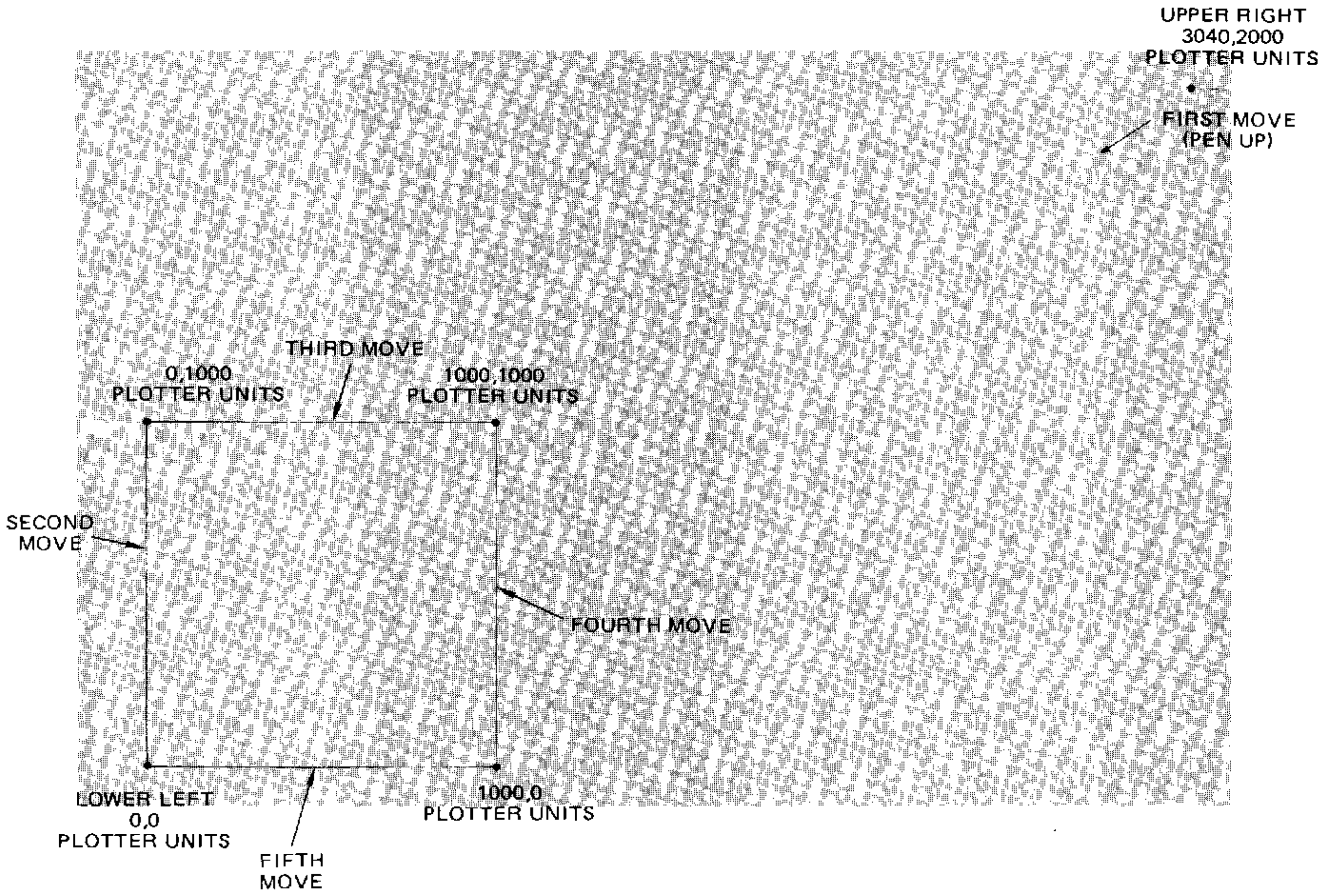


Figure 4-7. Performing a Move

The Incremental Draw

A user performs an incremental draw by program control. The following example performs an incremental draw from upper right to lower left:

Procedure Press the plotter front-panel UPPER RIGHT pushbutton.

Send	S	INCREMENTAL DRAW instruction
	] A @	X-parameter = -3040 plotter units (PMB format)
	> ! 0	Y-parameter = -2000 plotter units (PMB format)
	}	Terminator

Result Pen lowers and draws a line from upper right (point of origin = 0, 0 plotter units) to lower left (-3040, -2000 plotter units) as shown in Figure 4-8.

If an instruction specifies more than one incremental coordinate location, pen remains down and performs incremental draws in succession. The graphic position attained as the result of each draw becomes the point of origin for the following incremental coordinates. The following example assumes that the pen is at the lower left as the result of the preceeding draw.

Procedure	Send	S	INCREMENTAL DRAW instruction
		@ _ H	First draw X parameter 1000 plotter units (PMB format)
		SPACE	First draw Y parameter 0 plotter units (PMB format)
		@	Second draw X parameter 0 plotter units (PMB format)

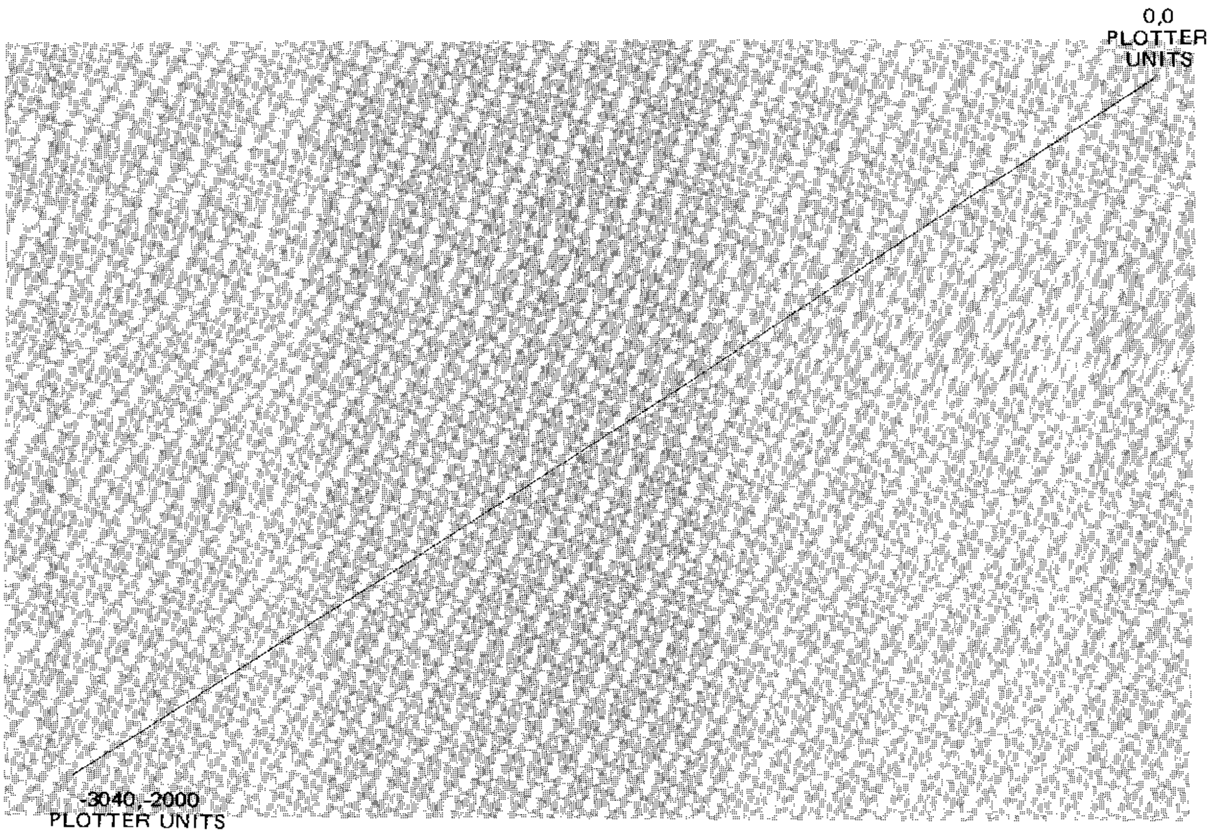


Figure 4-8. Performing an Incremental Draw

Procedure (Continued)	Send	SPACE ? (	Second draw Y parameter 1000 plotter units (PMB format)
		_ @ X	Third draw X parameter -1000 plotter units (PMB format)
		SPACE	Third draw Y parameter 0 plotter units (PMB format)
		@	Fourth draw X parameter 0 plotter units (PMB format)
		? SPACE 8	Fourth draw Y parameter -1000 plotter units (PMB format)
		}	Terminator

Result A square, 1000 x 1000 plotter units, is drawn as shown in Figure 4-9.

If one of the PMB coordinates specifies an increment that sends the pen outside of graph limits, the pen draws to the affected graph limit boundary upon receipt of the first character of the following parameter pair. At that boundary point the pen stops and raises. The pen remains in this position until a subsequent parameter of the same, or another, instruction returns the position of the pen to within the specified graph limits. The plotter calculates a vector from the exit point to the entrance point, and moves the pen in a raised state to the entrance point. At this point the pen is lowered and that portion of the draw which lies within the graphic limits is completed. The following example shows the effects of an out-of-limits incremental draw.

Procedure Press the plotter front-panel LOWER LEFT pushbutton.

Send	S	INCREMENTAL DRAW instruction
	O T	First draw X parameter 500 plotter units (PMB format)

4

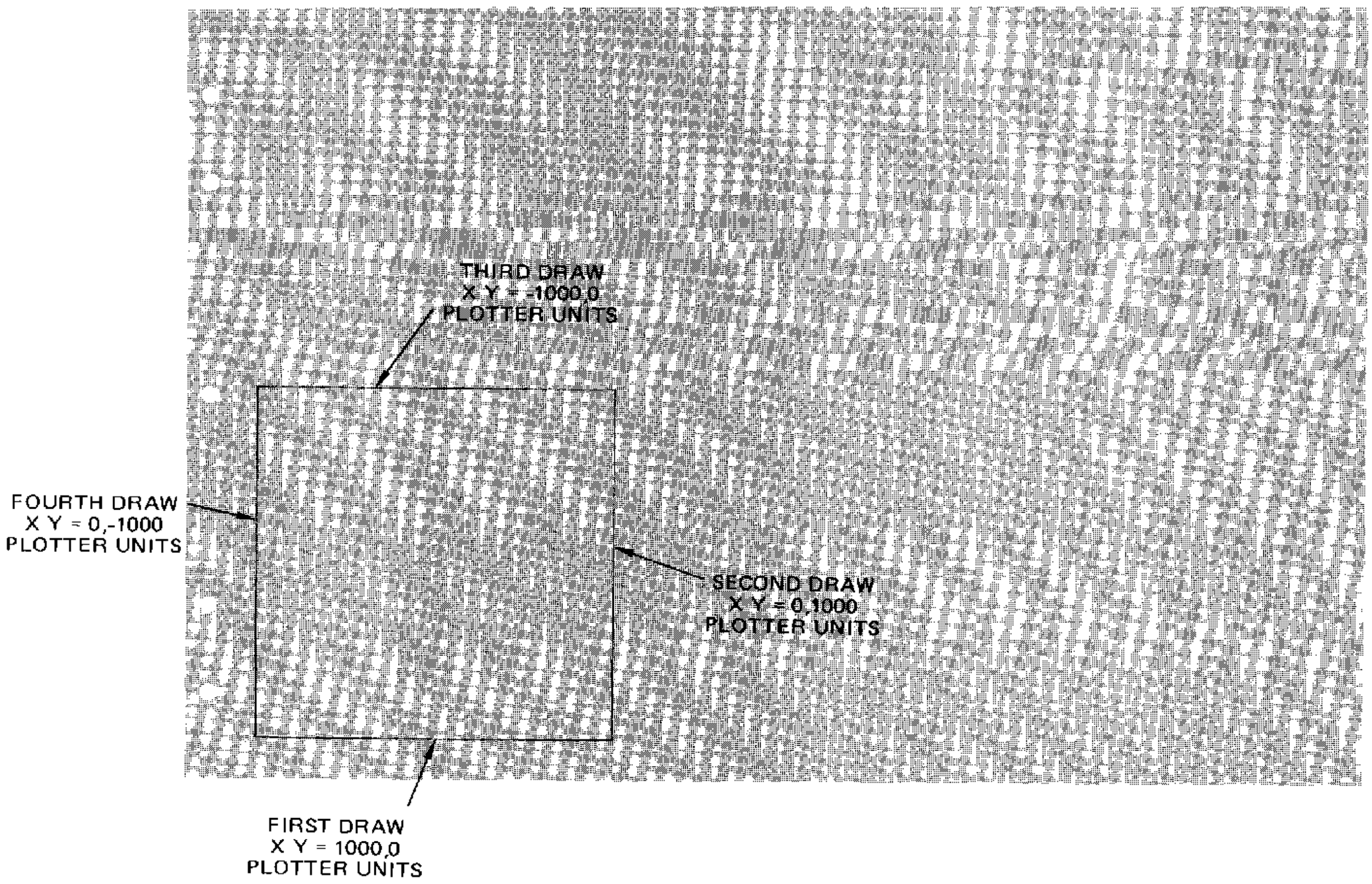


Figure 4-9. Performing Successive Incremental Draws

Procedure (Continued) Send

Send	
/ 4	First draw Y parameter 500 plotter units (PMB format)
O T	Second draw X parameter 500 plotter units (PMB format)
! > Ø	Second draw Y parameter 2000 plotter units (PMB format)
@ _ H	Third draw X parameter 1000 plotter units (PMB format)
= 1 <	Third draw Y parameter -2500 plotter units (PMB format)
}	Terminator

Result Plot is drawn as shown in Figure 4-10.

The Incremental Move

The incremental move differs functionally from the incremental draw only in the following ways:

a. The pen is initially raised. If there are no parameters in the incremental move instruction, the pen is raised in place with no change in position.

b. The vector described by the first parameter-pair of the incremental move instruction is executed with the pen raised. If there is only one parameter-pair, the move is made with the pen raised, and the pen remains up at the conclusion of the move. If there is more than one parameter-pair, the corresponding moves are executed with the pen lowered.

The following example draws the same plot as shown in Figure 4-10.

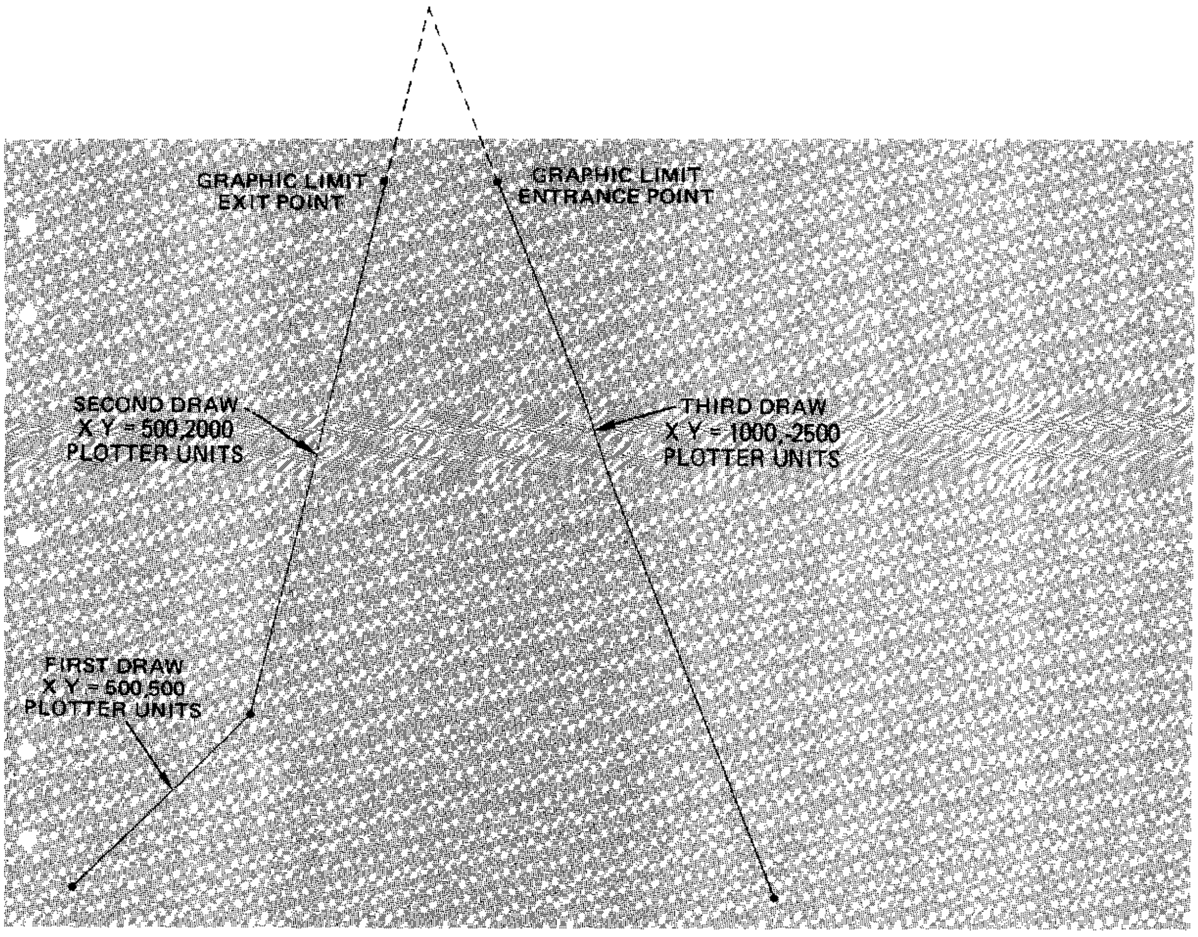


Figure 4-10. Performing an Out-of-Limits Incremental Draw

Procedure Press the plotter front-panel UPPER RIGHT pushbutton.

Send r	INCREMENTAL MOVE instruction
] A @	X-parameter = -3040 plotter units (PMB format)
> ! Ø	Y-parameter = -2000 plotter units (PMB format)
O T	First move X-parameter 500 plotter units (PMB format)
/ 4	First move Y-parameter 500 plotter units (PMB format)
O T	Second move X-parameter 500 plotter units (PMB format)
! > Ø	Second move Y-parameter 2000 plotter units (PMB format)
@ _ H	Third move X-parameter 1000 plotter units (PMB format)
= 1 <	Third move Y-parameter -2500 plotter units (PMB format)
}	Terminator

Result Pen moves from upper right to lower left with the pen up. Then the plot is drawn as shown in Figure 4-10.

Chapter 5
Labeling

Introduction

This chapter contains instructions for performing label operations on the plotter. The Label Mode is described, and the following topics are discussed.

- Overview
- The Label String
- The Label Group Instructions
- The Labeling Process (flow diagram)
- Character Definitions
- Default Specifications
- Invoking the Label Mode
- Locating the Label
- Terminating the Label Mode
- Designating the String Terminator
- Altering Character Size and Spacing
- Altering Character Slant
- Label Character Set Selection
- The Format Effectors
- The Left Label Margin
- Rotating the Label

Overview

Labeling is performed by the plotter while it is operating in the Label Mode, which is invoked by a LABEL MODE ON instruction. While the Label Mode is in effect, all data processed from the plot data buffer is interpreted as a string of ASCII characters to be drawn or acted upon. Drawn characters are produced using previously-established character font, size and slant specifications.

Labeling begins at the current pen position (the logical pen position in effect at the time the Label Mode is invoked). The direction of labeling is normally horizontal, left-to-right, but is subject to rotation produced by the ROTATE and ROTATE AT LAST ANGLE instructions. Labels are also subject to clipping at the graph limits.

The Label Mode is terminated when the previously-designated Label String Terminator is encountered and processed in the label string.

Default specifications for Standard and Alternate font designations, character size and slant, and label string terminator, are established in the plotter during Power-On and Initialize operations. Thereafter, they may be altered by plotter instructions. Once established, by default or by instruction, the labeling specifications remain effective for all subsequent Label Mode Operations, until programmatically changed. They cannot be altered within a label string, because graphic instructions cannot be executed while the Label Mode is invoked.

The Label String

The label string may contain any number of characters. The currently-designated label string terminator is considered part of the label string, and is the only required character in the string. The label string may contain any of the ASCII characters listed in Appendix D, except NUL, ENQ, ESC, or DEL. (These four characters are intercepted by the plotter's device control processor, and therefore are not stored in the plot data buffer.)

The characters in the label string are of two categories:

Control Characters (decimal equivalent values 00-32):
Of these, some have no labeling function and are ignored if they appear in the label string. The others function as label format effectors, or as character set selectors, and have no drawn representation. The functions of these characters are described later in this chapter, and in Chapter 10.

Graphic Characters (decimal equivalent values 33-126):
Each of the plotter's six available character sets provides a graphic (drawn) representation for every ASCII character in this category (refer to Appendix A).

The Label Group Instructions

The five plotter instructions listed below are directly associated with labeling, and are therefore referred to as the "Label Group".

Instruction Name	Purpose
LABEL FONT	Designate a Standard Font and an Alternate Font from among the six available character sets shown in Appendix A.
LABEL SIZE	Specify character size and spacing, in plotter units.
LABEL SLANT	Specify character slant angle, in degrees.
SET STRING TERMINATOR	Designate an ASCII code which is to be interpreted as the label string termination character.
LABEL MODE ON	Invoke the Label Mode in the plotter.

5

The Labeling Process

Figure 5-1 illustrates schematically how the Label Group instructions may be incorporated into a logical process to perform labeling.

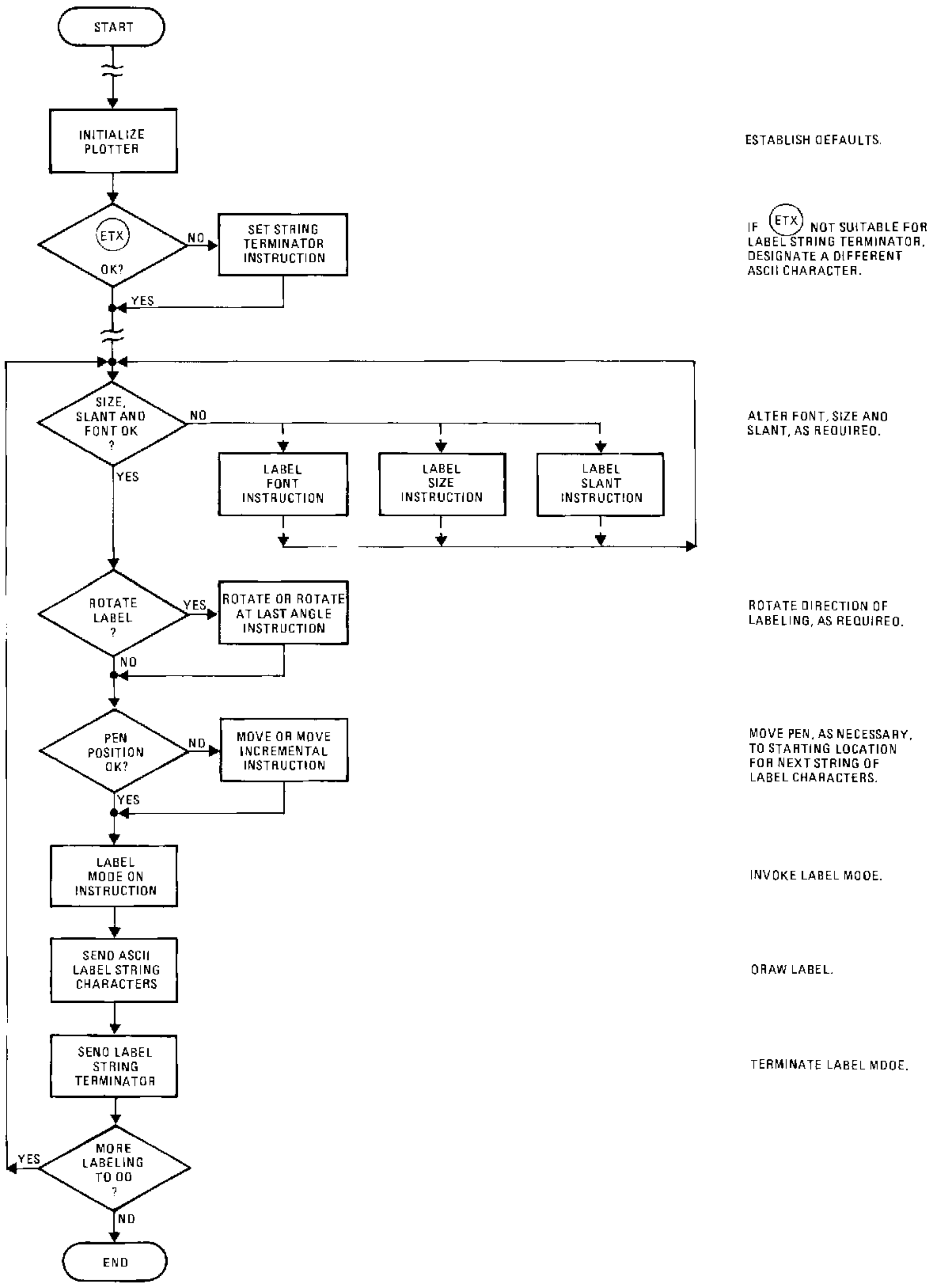


Figure 5-1. The Labeling Process

Character Definitions

In general, a drawn character is produced in an area of plotting space called the character cell, an imaginary rectangle or parallelogram which is illustrated in Figure 5-2. Character dimensions are related to the spacing dimensions in the manner indicated in the diagrams. The lower left corner of a character cell is referred to in this chapter as the character origin. The location of a character or symbol in plotting space is defined by the location of its character origin.

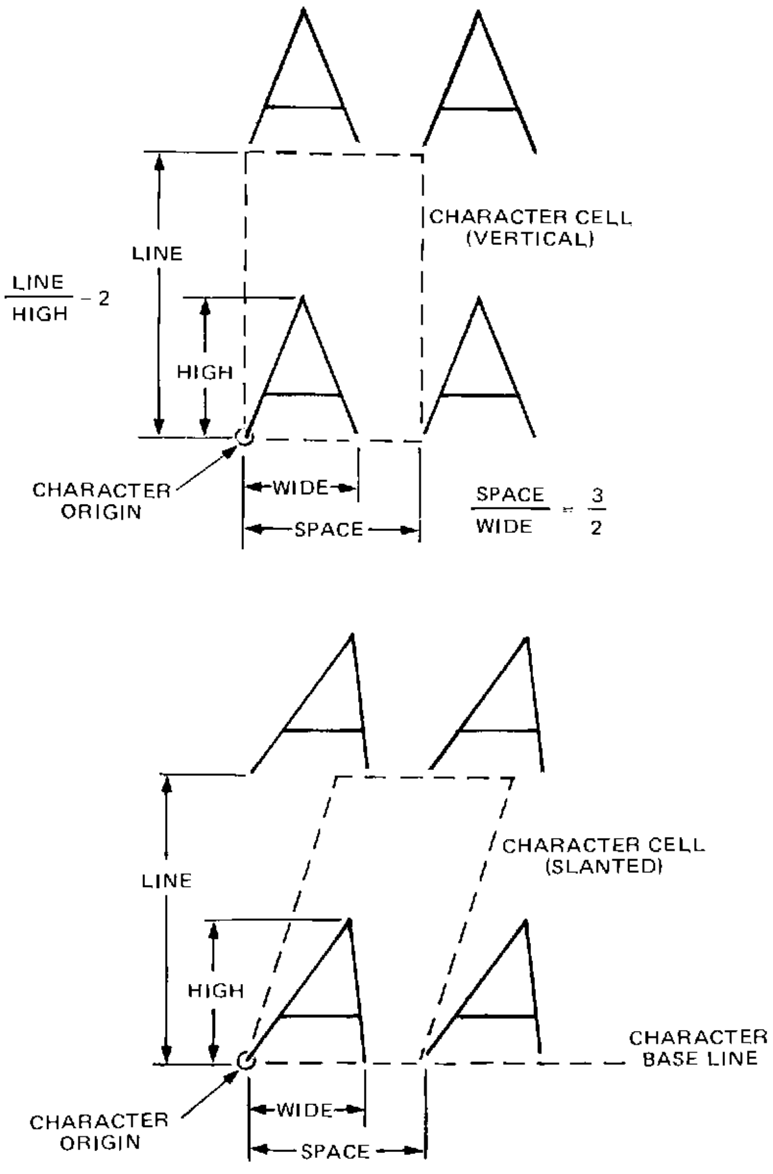


Figure 5-2. Character Definitions

Default Specifications

The following default specifications pertinent to labeling are established in the plotter during an Initialize operation:

Label Font:

Standard Font, Alternate Font = Character Set No. 0 (ANSI standard ASCII).

Label Size:

Line Spacing = 50 plotter units (LINE dimension in Figure 5-2).

Character Spacing = 25 plotter units (SPACE dimension in Figure 5-2).

Assuming default grid size and graph limits, this yields four lines per inch vertically, and eight characters per inch horizontally.

Label Slant:

Character slant angle = 90.0 degrees (vertical, "rectangular" characters).

Label String Terminator:

ETX character (equivalent numeric value = 03).

NOTES

In the exercise procedures described in this chapter, Carriage Return/Line Feed operations are denoted in the send sequence as CR LF. The meaning of the dashed circle is as follows: if the sending device automatically appends a LF character whenever a CR is generated, omit the LF in the send sequence. Otherwise, include it.

If the exercise procedures are performed from a terminal keyboard, some of the ASCII characters (particularly the control characters) may require use of the CONTROL key on the keyboard. Refer to the terminal's user manual or to Appendices A and D in this manual for this information.

Invoking The Label Mode

The Label Mode is invoked in the plotter when the LABEL MODE ON instruction is processed from the plot data buffer. Subsequent data, up to and including the label string terminator, is drawn or acted upon as a string of label characters.

Procedure

Depress [ENTER •] [CHART HOLD] [LOWER LEFT] on the plotter front panel (Initialize).

Send	(ESC) (.) (()	PLOTTER ON instruction.
	(~) (')	LABEL MODE ON instruction.*
	(L) (A) (B) (E) (L)	Label String (ASCII characters).
	(ETX)	Default String Terminator.

*In LOCAL mode only, the character (STX) can be substituted for (~) (')

Result (Refer to Figure 5-3)

The word "LABEL" is drawn, beginning at the lower left graph limit position, utilizing the default Standard font and the default values for character size and slant established by the Initialize process. The Label Mode is terminated by (ETX).

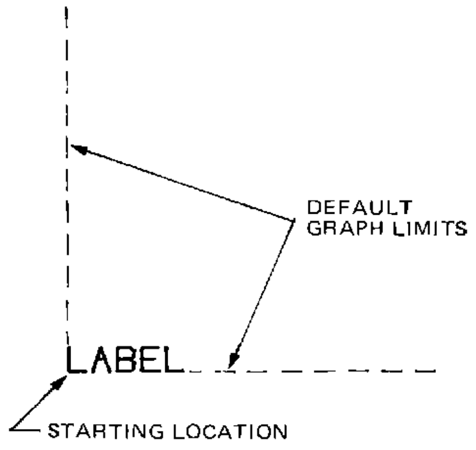


Figure 5-3. Labeling with Default Specifications

Locating The Label

Labeling begins at the current pen position if it is within the specified graphic limits. Specifically, the character origin (refer to Figure 5-2) of the first label character position is located at the pen position in effect when the label mode is invoked.

Thus, a label may begin at the pen position attained at the completion of any of the following plotter instructions: MOVE, DRAW, INCREMENTAL MOVE, INCREMENTAL DRAW, ARC CLOCKWISE, or ARC COUNTER-CLOCKWISE. Customarily, labels are located by issuing a MOVE or INCREMENTAL MOVE just prior to the LABEL MODE ON instruction.

Procedure

Send	p f Q $	MOVE to coordinate location 100, 100.
	~ '	LABEL MODE ON instruction.
	M O V E	Label string characters.
	ETX	Default string terminator.

Result (Refer to Figure 5-4)

The word "MOVE" is drawn with the character origin of the letter "M" located at location 100, 100, as specified by the MOVE instruction.

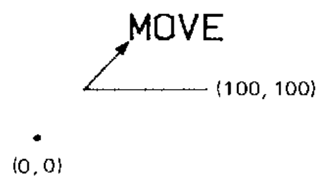


Figure 5-4. Locating a Label Via the MOVE Instruction

Consecutive LABEL MODE ON instructions cause their label strings to be drawn as if they were one continuous label string. Labels may also be located by the manual pen controls on the plotter front panel.

Procedure

Use the "arrow" pushbuttons on the front panel to position the pen.

Send	~ '	LABEL MODE ON instruction.
	1 9 ETX	Draw "19" and terminate.
	~ '	LABEL MODE ON instruction.
	7 7 ETX	Draw "77" and terminate.

Result (Refer to Figure 5-5)

The legend "1977" is drawn in two contiguous segments, and is located at any convenient position by the front panel controls on the plotter.

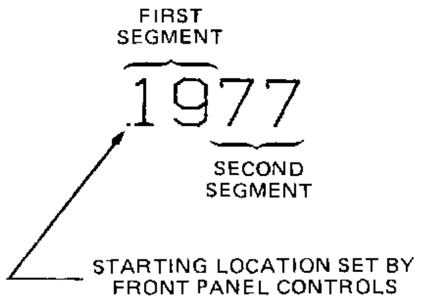


Figure 5-5. Contiguous Label Segments

Once the Label Mode is invoked, it can be terminated only by one of the following means:

1. Recognition of the currently-designated string terminator in the label string.
2. A Graphics Abort sequence ESC . K
3. An Initialize operation generated from the plotter front panel.
4. Power-Off/Power-On sequence.

Loss or omission of the string terminator causes subsequent characters, which are intended as instruction codes and parameter data, to be treated by the plotter as label string characters.

Procedure

Send	~ '	LABEL MODE ON instruction.
	s t o p SPACE	Label string.
	ETX (Omit this character)	String terminator.
	t a SPACE	ARC CLOCKWISE instruction.
	}	NOP (Instruction delimiter).

Result (Refer to Figure 5-6)

When the ETX is omitted, the subsequent ARC CLOCKWISE instruction is drawn as a label (Detail A), rather than executed (Detail B).

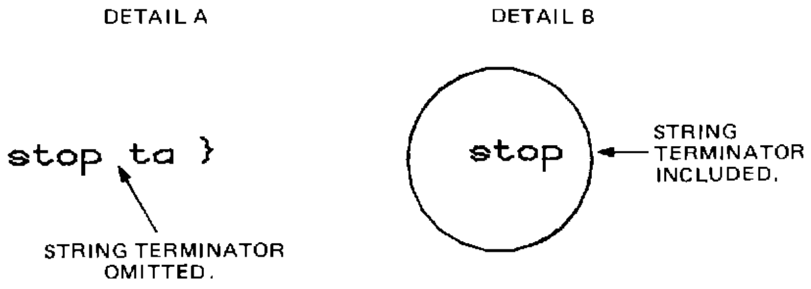


Figure 5-6. Omission of a String Terminator

Designating The String Terminator

If the default string terminator ETX is not suitable for the particular application, any other ASCII character code except NUL, ENQ, ESC, or DEL may be substituted, by designating the desired character in a SET STRING TERMINATOR instruction.

Procedure

Send		
	~ \	SET STRING TERMINATOR instruction.
	j	MBN parameter = 10 (designates LF as label string terminator).
	~ '	LABEL MODE ON instruction.
	s t o p SPACE	Label string characters.
	ETX	"Phantom" terminator.
	n o w	Label string, continued.
	CR LF	Carriage Return and Line Feed. (Terminate the Label Mode.)
	t a SPACE	ARC CLOCKWISE instruction.
	}	Instruction delimiter.

Result (Refer to Figure 5-7)

The LF character is designated as the label string terminator, replacing ETX. The label sequence includes ETX as a "phantom" character to show that it has no effect. The label mode terminates after LF is executed as a format effector, which is its normal function in a label string.

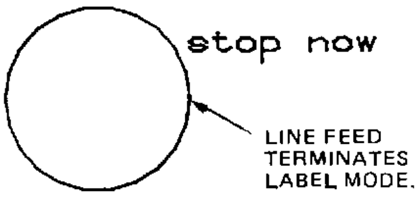


Figure 5-7. Designating a New String Terminator

Note that if the sending device automatically includes a line feed with a carriage return, LF should still be the designated string terminator rather than CR, even though LF is not specifically entered as a label string character.

The default string terminator can be re-designated by omitting the parameter from the SET STRING TERMINATOR instruction.

Procedure

Send	~ \	SET STRING TERMINATOR instruction.
	~ '	LABEL MODE ON instruction.
	s t o p SPACE	Label string characters.
	ETX	Default string terminator.
	t a SPACE	ARC CLOCKWISE instruction.
	}	Instruction delimiter.

Result (Refer to Figure 5-6, Detail B)

ETX is redesignated as the string terminator. The subsequent label and circle are drawn the same as in Detail B of Figure 5-6.

Altering Character Size And Spacing

The size of individual characters, and the horizontal and vertical spacing between them, is specified by the LABEL SIZE instruction. Figure 5-8 illustrates the relationships between spacing and character size. The LABEL SIZE instruction specifies the line-spacing dimension (LINE) and the character-spacing dimension (SPACE); and the character dimensions are thereby implied. Both dimensions are treated in plotter units, so the actual drawn dimensions depend on grid size and graph limits. The default values are LINE = 50 plotter units, SPACE = 25 plotter units.

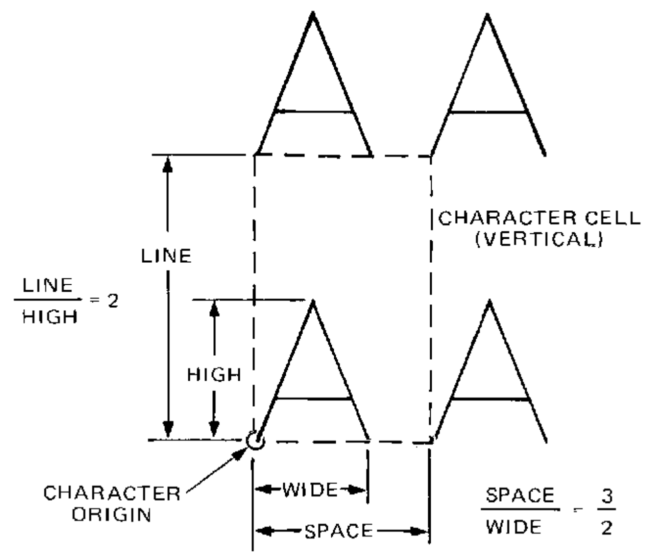


Figure 5-8. Character Line and Space Definitions

Procedure

Send	~ %	LABEL SIZE instruction.
	‘ − I X	Specify SPACE = 90, LINE = 600. (in MBP parameter format)
	~ ′	LABEL MODE ON instruction.
	T A L L CR LF t h i n ETX	Label String, with terminator.

Result (Refer to Figure 5-9)

The legend $\substack{\text{TALL}\\\text{thin}}$ is drawn, with character and line spacing equal to 90 and 600 plotter units, respectively. The upper-case alphabetic characters are each 60 plotter units wide and 300 plotter units high. The CR LF sequence places the character origin of the "t" in "thin" 600 plotter units below that of the "T" in "TALL".

Character and Line spacing revert to their default values if the parameters are omitted from the LABEL SIZE instruction.

Procedure

Send	~ %	LABEL SIZE instruction.
	~ ′	LABEL MODE ON instruction.
	L A B E L ETX	Label string and terminator.

Result The word "LABEL" is drawn in default size (LINE = 50, SPACE = 25 plotter units).

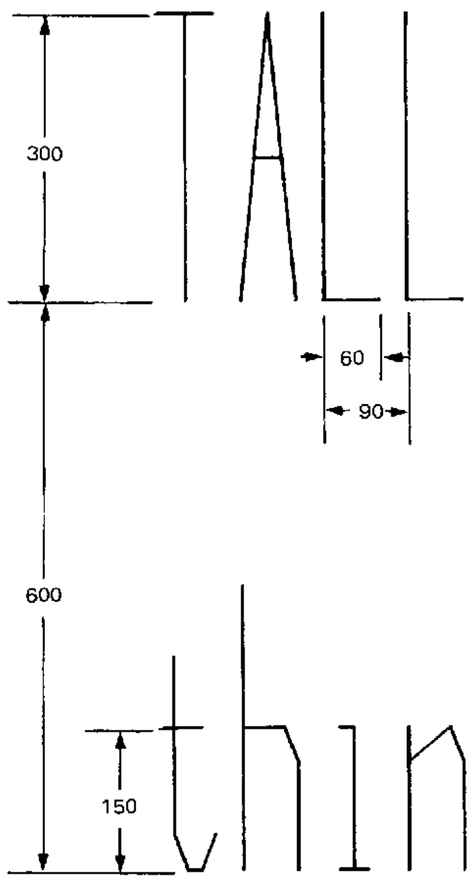


Figure 5-9. Specifying LINE, SPACE

5

Altering Character Slant

The slant of individual characters in a label is specified by the LABEL SLANT instruction. The slant angle is the angle of the left side of the character cell, measured counter-clockwise from the character base line. (Refer to Figure 5-10.) Note that the vertical height of characters and the line spacing are not affected by the slant angle.

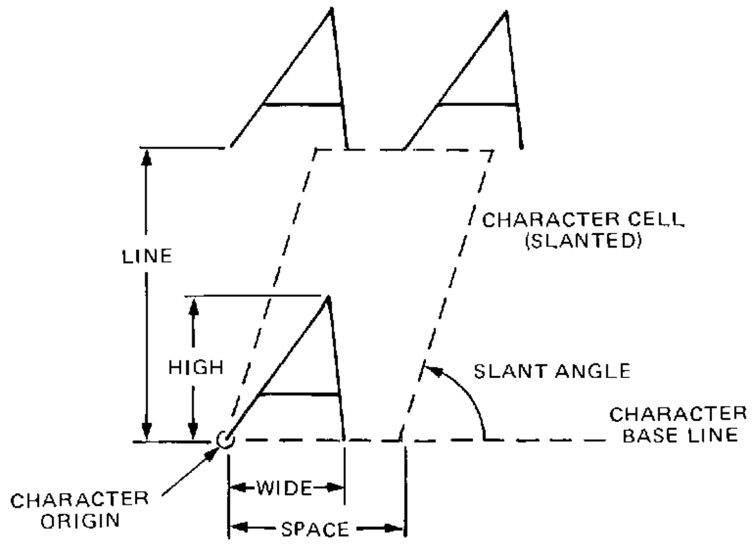


Figure 5-10. Character Slant Angle

The default slant angle is 90.0 degrees, which produces vertical, rectangular characters. Slant angles between 0.0 and 90.0 degrees produce characters with a " forward" slant; while angles between 90.0 and 180.0 degrees produce a "backward" slant.

Procedure

Send	~ /	LABEL SLANT instruction.
	c	MBA parameter: Angle = 67.5 degrees.
	~ '	LABEL MODE ON instruction.
	H P CR LF ETX	Label string and terminator.
	~ /	LABEL SLANT instruction.
	e	MBA parameter: Angle = 112.5 degrees.
	~ '	LABEL MODE ON instruction.
	H P ETX	Label string and terminator.

Result (Refer to Figure 5-11)

The legend "HP" is drawn twice, with slant angles of 67.5 and 112.5 degrees, respectively. Note that the LABEL SLANT instruction alters the slant of individual characters with respect to the base line of lettering; it does not alter the angle of rotation of the line of lettering. Note also that the line-feed operation causes a displacement perpendicular to the base-line of lettering, regardless of the slant angle.

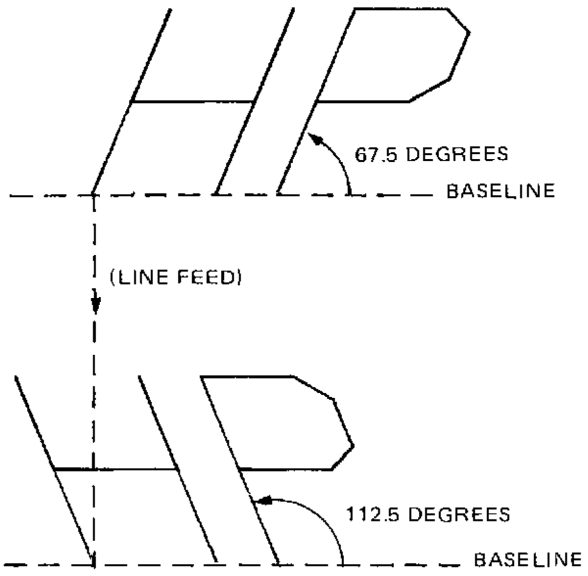


Figure 5-11. Forward and Backward Slants

Angles specified greater than 180.0 degrees are treated by the plotter as values 180.0 less than the specified value, so that the subsequent characters are not inverted.

Procedure

Send	~ /	LABEL SLANT instruction.
	k	MBA parameter: Angle = 247.5 degrees.
	~ '	LABEL MODE ON instruction.
	H P CR LF ETX	Label string and terminator.
	~ /	LABEL SLANT instruction.

Procedure (Continued)

Send	m	MBA parameter: Angle = 292.5 degrees.
	~ '	LABEL MODE ON instruction.
	H P ETX	Label string and terminator.

Result The specified slant angles of 247.5 and 292.5 degrees are treated as 67.5 and 112.5 degrees, respectively. The labels appear identical to those of Figure 5-11.

The slant angle reverts to its default value of 90.0 degrees if the MBA parameter is omitted from the LABEL SLANT instruction.

5

Procedure

Send	~ /	LABEL SLANT instruction.
	~ '	LABEL MODE ON instruction.
	H P ETX	Label string and terminator.

Result The legend "HP" is drawn with vertical, rectangular characters.

Label Character Set Selection

Standard And Alternate Fonts

The plotter can draw graphic characters from any of six available character sets herein after called fonts. Appendix A shows, for each ASCII graphic character, the corresponding drawn symbol or character in each of the six fonts. Prior to invoking the label mode, one of the six fonts is designated as the **Standard Font**, and another or the same font is designated as the **Alternate Font**. After the label mode is invoked, the ASCII graphic characters in the label string are processed using either the Standard Font or the Alternate Font -- whichever of the two is currently selected.

Initialize operations automatically designate Font No. 0 (the ANSI Standard ASCII character set) as both Standard and Alternate Font, and select the Standard Font for label processing.

Changing The Label Font

Selecting a particular font for label processing can involve two steps:

1. **Designate** that particular font as either the Standard or the Alternate Font, via the LABEL FONT instruction, prior to invoking the Label Mode.

2. **Select** the currently-designated Standard or Alternate Font, as appropriate, after the Label Mode is invoked. This is accomplished by two control characters which can appear in the label string: (refer to Appendix D for Control Character listing).

   SO implies "select the Alternate Font";

   SI implies "select the Standard Font".

Procedure

Send	~ P	LABEL FONT instruction.
	` %	MBP parameter: Std = 1, Alt = 5.
	~ '	LABEL MODE ON instruction.
	{ 7 2 2 1 } SPACE f o n t s	Graphic characters to be drawn from Standard Font (Font No. 1).
	CR LF	Move to next line of lettering.
	SO	Switch to Alternate Font.
	{ 7 2 2 1 } SPACE f o n t s	Graphic characters to be drawn from Alternate Font (Font No. 5).
	ETX	Label string terminator.

Result (Refer to Figure 5-12)

Character sets 1 and 5 are designated as the Standard and Alternate Fonts, respectively. Then two identical sequences of ASCII characters are drawn: first from the Standard Font (because the standard font is automatically invoked by plotter initialization); then from the Alternate Font, which is invoked by the character SO in the label string.

FONT NO. 1 (STANDARD) π7221→ fonts

FONT NO. 5 (ALTERNATE) {7221} ≡ΣΠ←↑

Figure 5-12. Font Selection

5

Since the Alternate Font is now the currently-selected font, a label can be drawn using a different font by re-designating the Alternate Font.

Procedure

Send	~ P	LABEL FONT instruction.
	g	MBP parameter: Std = 1, Alt = 3.
	~ '	LABEL MODE ON instruction.
	{ 7 2 2 1 } SPACE f o n t s	Graphic characters to be drawn from Alternate Font (Font No. 3).
	CR LF	Move to next line of lettering.
	SI	Switch to Standard Font.
	{ 7 2 2 1 } SPACE f o n t s	Graphic characters to be drawn from Standard Font (Font No. 1).
	ETX	Label string terminator.

Result (Refer to Figure 5-13)

The Alternate Font is re-designated as Font No. 3, and the same sequence of ASCII characters is drawn from the Alternate Font. The Standard Font is then selected and the character sequence is repeated. Note that the *umlaut* characters in Font No. 3 imply an automatic backspace.

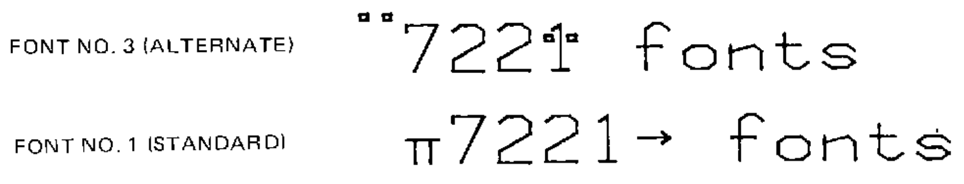


Figure 5-13. Re-designated Alternate Font

Designation of the Standard and Alternate fonts reverts to Font No. 0, the default, if the MBP parameter is omitted from the LABEL FONT instructions.

Procedure

Send	~ P	LABEL FONT instruction.
	~ '	LABEL MODE ON instruction.
	{ 7 2 2 1 } ETX	Label string and terminator.

Result (Refer to Figure 5-14)

The label is produced using the ANSI Standard ASCII Character Set (Font No. 0).

FONT NO. 0 {7221}

Figure 5-14. Reverting to the Default Font

The Format Effectors

Several of the ASCII control codes (decimal equivalent values 00-32) cause "non-printing" label functions to be performed when they are processed as label string characters. The functions of these **format effectors** are generally self-explanatory, or can be related to similar functions on a typewriter. (Refer to Table 5-1.)

Table 5-1. Format Effectors

ASCII Character	Name of Label Format Function	Analogous Function or Effect on a Typewriter
CR Carriage Return	Carriage Return* (move pen to left margin)	Carriage Return (without automatic line index)
LF Line Feed	Line Feed (move pen down one line)	Index (roll paper up one line)
VT Vertical Tab	Inverse Line Feed (move pen up one line)	(roll paper down one line)
FF Form Feed	Set Label Origin	Set Left Margin
SPACE Forward Space	Forward Space	Space
BS Backspace	Backspace*	Backspace
HT Horizontal Tab	Forward Half-space	Half-space

*Unlike its typewriter counterpart, the Backspace format effector BS can produce backspacing to the left of the left margin. From that position, the CR character causes a return *to the right*, to reach the left margin.

The Left Label Margin

The left label margin, as herein discussed, is an imaginary line which is perpendicular to the baseline of lettering, and passes through a logical point called the label origin. When a CR character is processed, the pen and the current character origin are moved to the current location of the label origin, on the left margin. The label origin is moved, one line-space at a time, up and down along the left margin by the VT and LF format effectors. There is no logical right margin for labeling.

The following procedure illustrates the effects of the CR, VT and LF characters.

Procedure

Send ~ ' — LABEL MODE ON instruction.

A A VT B B LF
C C LF D D CR (LF)
E E ETX — Label String and Label Terminator.

Result (Refer to Figure 5-15)

In the illustration, the arrows show the movements of the current character origin produced by the indicated format effectors. The heavy dots represent the corresponding positions taken by the label origin.

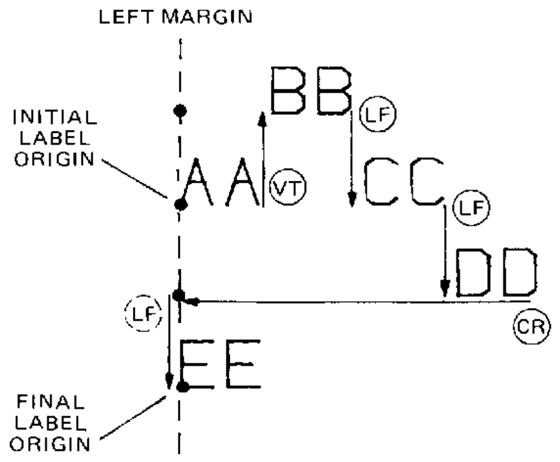


Figure 5-15. The Label Origin and Left Margin

Establishing The Left Margin

Prior to invoking the Label Mode, the left margin is established when a label origin is located by any of the following means:

Power-On and Initialize Operations. The label origin is reset to the lower-left graph limit position. The left margin is coincident with the left graph limit.

Plotter Front Panel Cursor Controls. The label origin is established at the pen position attained when the pushbuttons are released.

Absolute MOVE and DRAW Instructions. The label origin is established at the endpoint of the vector specified by the instruction.

When the front panel controls or the MOVE or DRAW instructions are used to determine the starting location of a label, the label origin is automatically located at the same point. This is not the case when the starting location is determined by an INCREMENTAL MOVE, INCREMENTAL DRAW, ARC CLOCKWISE or ARC COUNTER-CLOCKWISE instruction. These instructions cause pen movements to be generated incrementally, and do not affect the label origin and left margin.

Procedure

Send	~ % c A SPACE	Set Label Size
	p d @ H @	MOVE to location (512, 512)
	~ '	LABEL MODE ON instruction.
	A A ETX	Draw A's, and terminate.
	t a @ o	ARC CLOCKWISE instruction.
	~ '	LABEL MODE ON instruction.
	CR LF B B	Draw B's under the A's.
	ETX	Terminate label mode.

Result (Refer to Figure 5-16)

The first label segment, "AA", and the label origin, are located by a MOVE instruction. A circle is drawn around the A's using an ARC CLOCKWISE instruction. The circle starts and ends at the character origin adjacent to the second "A". Since this instruction does not affect the label origin, the CR LF operation in the second label segment places the characters "BB" directly under the A's, against the left margin originally established for the label.

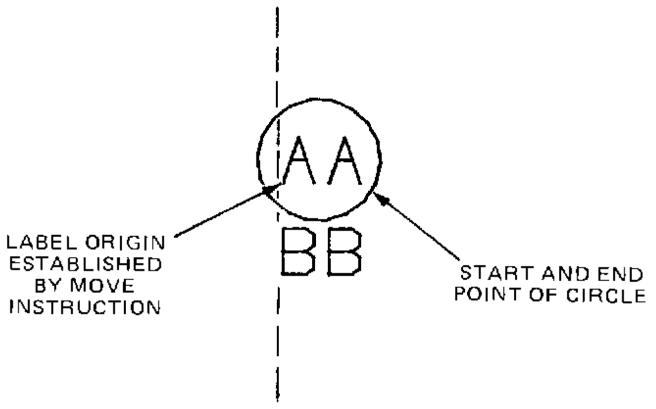


Figure 5-16. Establishing and Preserving the Left Margin

Moving The Left Margin

While the Label Mode is invoked, the left margin can be moved by re-establishing the label origin using either of two methods:

Plotter Front Panel Cursor Controls. The arrow pushbuttons are effective while the Label Mode is invoked. Label execution is suspended while the pushbuttons are depressed, and the new label origin is established when they are released.

Set Label Origin Character. The FF format effector causes the label origin to be relocated to the current character origin.

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Procedure

Move pen to any convenient location.

Send	~ '	LABEL MODE ON instruction.
	A A FF	Draw A's and move margin.
	B B	Draw B's.
	CR LF C C	Draw C's under the B's.
	ETX	Terminate Label Mode.

Result (Refer to Figure 5-17)

A new margin is established by moving the label origin to the character origin current when the FF character is processed.

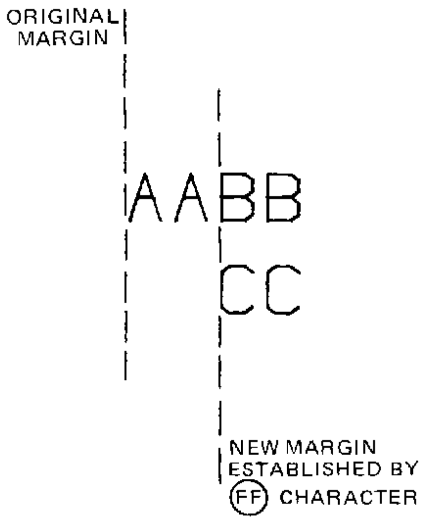

Figure 5-17. Using "Set Label Origin"

Rotating The Label

The direction of labeling can be rotated by plotter instructions or by use of the plotter front panel controls.

Procedure

Send	p f @ L @	MOVE to location (768, 768).
	q h @ H @	DRAW to location (1024, 512).
	x	ROTATE AT LAST ANGLE instruction.
	~ '	LABEL MODE ON instruction.
	L A S T CR LF A N G L E SPACE	First label string.
	ETX	Terminator.
	w d	ROTATE 90.0 degrees.
	~ '	LABEL MODE ON instruction.
	FF	Reset label origin.
	N E W CR LF A N G L E	Set label string.
	ETX	Terminator.

Result (Refer to Figure 5-18)

The first label is drawn in the direction of the vector produced by the DRAW instruction; the second label is rotated 90.0 degrees from the first one. Note that the label margin also

rotates so that it remains perpendicular to the baseline of lettering. The reason for including the FF character in the second label can best be seen by repeating the procedure, omitting the FF in the send sequence.

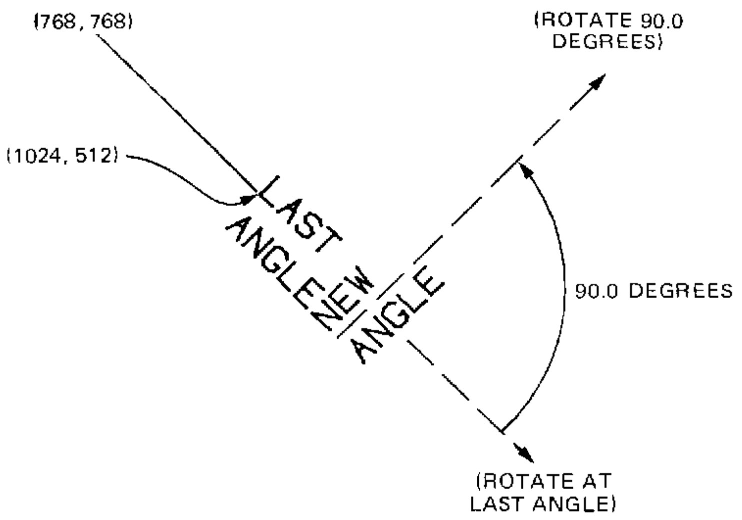

Figure 5-18. Label Rotation

By depressing ENTER, followed by any of the "arrow" pushbuttons on the front panel, the direction of labeling is rotated to the direction of the arrow (see Figure 5-19). This function can be performed in LOCAL mode only.

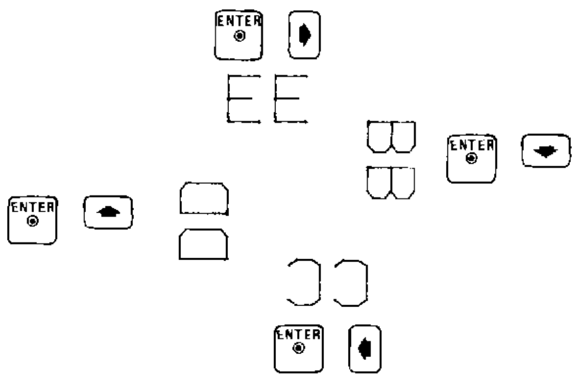

Figure 5-19. Rotating Labels From Front Panel (LOCAL mode only)

Chapter 6
Extended Graphic Instructions

Introduction

This chapter describes the following functions:

- Drawing Circles
- Drawing Arcs
- Arc Tolerance
- Rotate Instruction
- Rotate At Last Angle
- Fixed Dash Line Plotting
- Variable Dash Line Plotting
- Terminating The Dash Line Mode

Drawing Circles

Circles and arcs are plotted in either a clockwise (CW) direction or, a counterclockwise (CCW) direction, with the current pen position being the point of circle origin as shown in Figure 6-1.

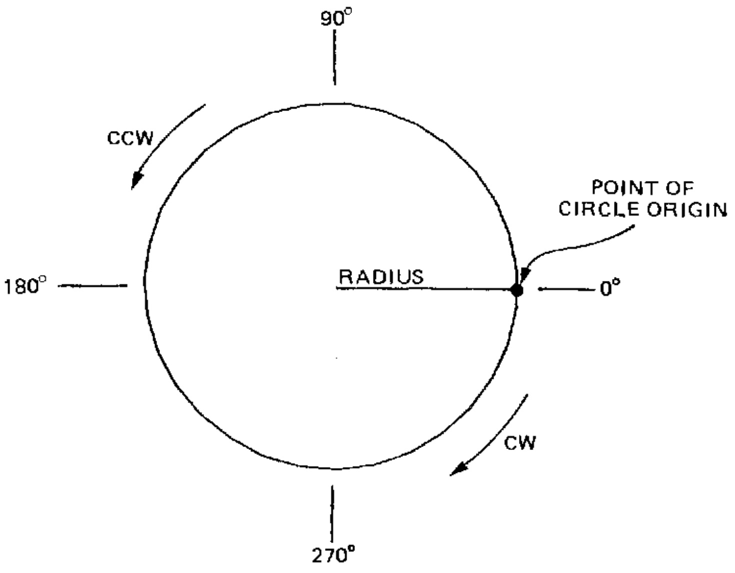

Figure 6-1. Circle Plot

Clockwise Circles

To draw a circle in a clockwise direction, proceed as follows:

Procedure	Send	t	ARC CLOCKWISE instruction
		d @	Radius parameter, 256 plotter units (MBN format).
		}	Terminator (NOP)

Result A circle with a radius of 256 plotter units is drawn in a clockwise direction. See Figure 6-2. The actual plot made with the foregoing procedure is shown in Detail A, Figure 6-22.

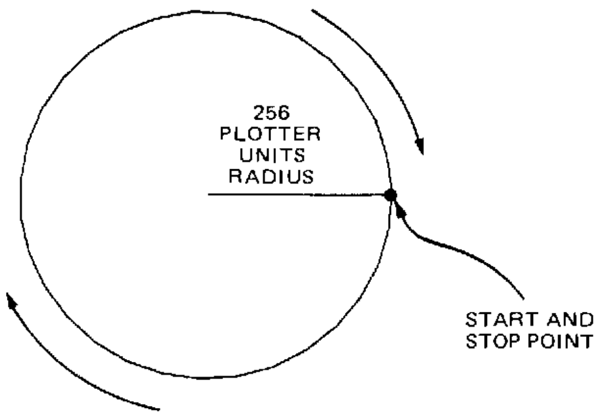

Figure 6-2. Arc Clockwise

Counterclockwise Circles

To draw the same circle in a counterclockwise direction:

Procedure	Send	u	ARC COUNTERCLOCKWISE instruction.
		}	Terminator (NOP).

Result Retrace the circle just plotted in a counterclockwise direction (see Figure 6-3). Note that when no new radius parameter is specified, the plotter uses the last radius parameter received for the new instruction. The actual plot drawn with the instruction is shown in Detail A, Figure 6-22.

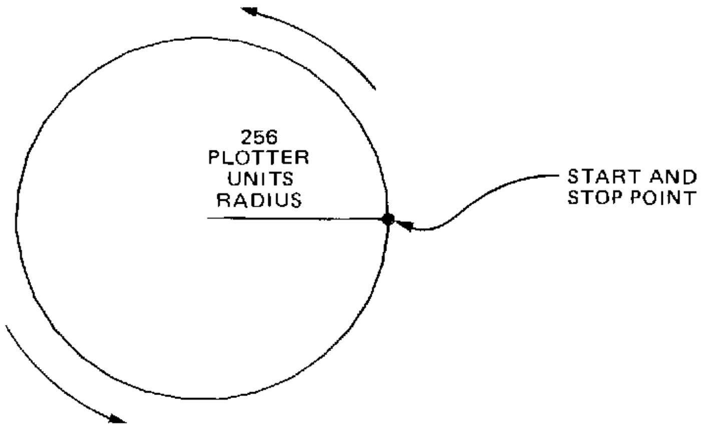

Figure 6-3. Arc Counterclockwise

Changing Start-Stop Points

To change the start-stop point on a circle, proceed as follows:

Procedure	Send	t	ARC CLOCKWISE instruction.
		d @	Radius parameter, 256 plotter units (MBN format).
		h	Start Angle parameter, 180° (MBA format).
		}	Terminator.

Result A circle with a radius of 256 plotter units is drawn in a clockwise direction. As a start angle of 180° is given, the current pen position, which had been the 0° point of origin when no start angle was given, now becomes the 180° point of origin. The clockwise plot is from 180° through 0°/360° back to the 180° point of origin (see Figure 6-4). The actual plot is shown in Detail B, Figure 6-22.

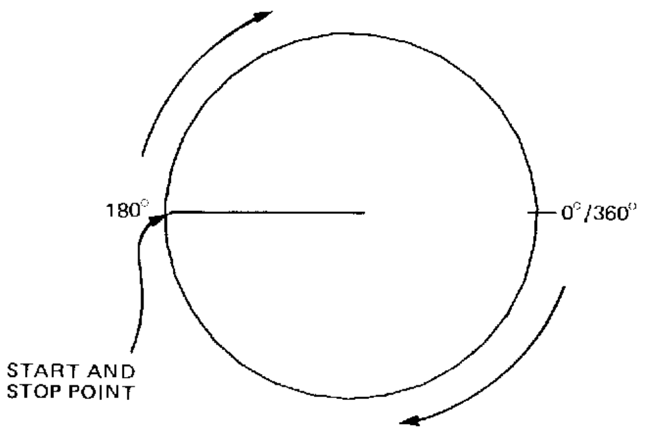

Figure 6-4. Start Angle 180°

Drawing Arcs

Having plotted clockwise and counterclockwise using a start angle, drawing an arc is performed by adding a stop angle. This function is performed as follows:

Procedure	Send t	ARC CLOCKWISE instruction.
	c @	Radius parameter, 192 plotter units (MBN format).
	h	Start Angle parameter 180° (MBA format).
	k	Stop Angle parameter 247.5° (MBA format).
	}	Terminator.

Result Draws an arc in a clockwise direction from the 180° point of origin, through the 0°/360° to the 247.5° point (see Figure 6-5). The plot is shown in Detail B, Figure 6-22.

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Arcs generated by the plotter are circular in the default plotter unit coordinate system. Plotted arcs will also be circular if the SET GRID SIZE instruction defines a square grid. If a square grid has not been set up, the plotted arcs will be elliptical.

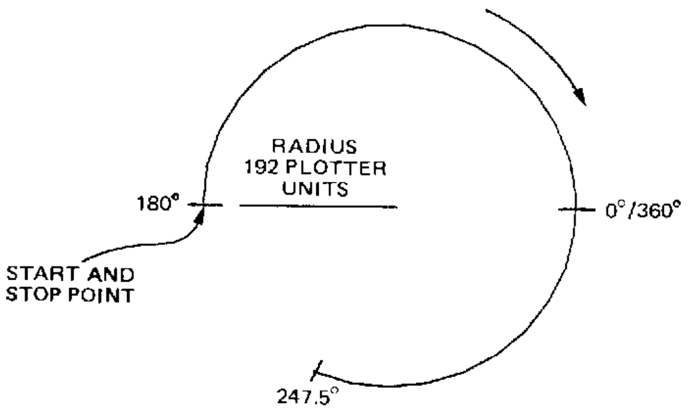

Figure 6-5. Arc From 180° To 247.5°

Arc Tolerance

When the plotter receives an Arc instruction the plotter actually generates a series of chords that are used to approximate the required arc. The distance between these internally generated chords and the required arc, stated in plotter units, are specified in the ARC TOLERANCE instruction. See Figure 6-6.

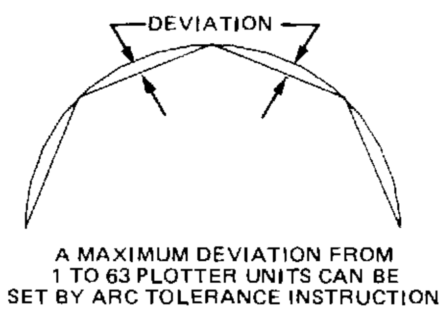

Figure 6-6. Arc Tolerance Deviation

The number of straight line chords used to draw an arc varies according to the radius and the arc tolerance used; however, the minimum number of chords the plotter uses to draw a circle is eight.

It should be noted that smaller tolerances result in more chords being drawn which, in turn, produces a smoother arc. The more chords drawn the more time it takes to plot.

Worse Case Arc Tolerance

The following sample plot illustrates "worst case" arc tolerance.

Procedure	Send	~ T	ARC TOLERANCE instruction.
		?	Arc tolerance 63 plotter units (SBN format).
		t	ARC CLOCKWISE instruction.
		f P	Radius parameter 400 plotter units (MBN format).
		}	Terminator.

Result Draws a circle with a "worst case" arc tolerance. Circle is approximated by eight chords (see Figure 6-7). The actual plot is shown in Detail C, Figure 6-22.

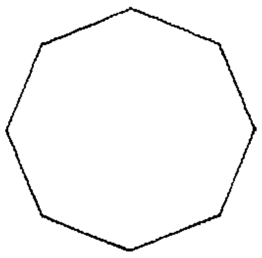

Figure 6-7. Arc Tolerance of 63 Plotter Units

Decreasing Arc Tolerance

By decreasing the arc tolerance, a smoother circle is plotted using more chords and taking a longer execution time as follows:

Procedure	Send	~ T	ARC TOLERANCE instruction.
		H	Arc tolerance 8 plotter units.
		t	ARC CLOCKWISE instruction.
		}	Terminator.

Result Draws a circle with an arc tolerance of 8 plotter units which uses 16 chords. Notice that the radius parameter used is the last one the plotter received (see Figure 6-8). The plot made by the instruction is shown in Detail C, Figure 6-22.

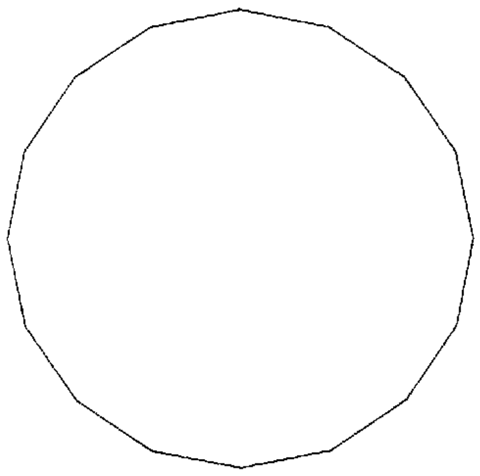

Figure 6-8. Arc Tolerance of 8 Plotter Units

Default Arc Tolerance

The default value for the Arc Tolerance is 1 plotter unit, which provides the best possible arc or circular plot. If the Arc Tolerance instruction is sent without a tolerance being specified, the plotter reverts to its default value of 1 plotter unit as follows:

Procedure	Send ~ T	ARC TOLERANCE instruction.
	t	ARC CLOCKWISE instruction.
	}	Terminator.

Result Draws a circle with an arc tolerance of 1 plotter unit (see Figure 6-9). The actual plot is shown in Detail C, Figure 6-22.

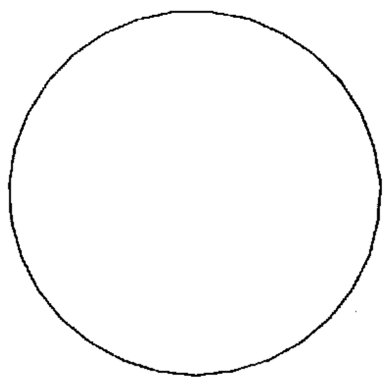

Figure 6-9. Arc Tolerance of One Plotter Unit

Rotate Instruction

The Rotate instruction affects all vectors except absolute moves and draws. Each instruction allows the affected vectors to be rotated counterclockwise about their starting points with the specified angle being added to the current rotation angle in effect. If no previous angle is specified, it is added to zero degrees, which is the default value of the rotation parameter.

Like the ARC instruction, the ROTATE instruction assumes a square grid has been set up with the SET GRID SIZE instruction; otherwise, the plotted angles incline more toward the stretched axis. To demonstrate the Rotate instruction a four sided box is drawn, then rotated and labeled as follows:

Drawing A Square

Procedure	Send S	INCREMENTAL DRAW instruction.	
	@ @) ,	First move	↑
	I L SPACE SPACE	Second move	→
	@ @ 6 4	Third move	↓
	V T SPACE SPACE	Fourth move	←
	|	Terminator.	

Result Draws a four sided box, each side being 300 plotter units in length (see Figure 6-10). The actual square is shown in Detail D, Figure 6-22.

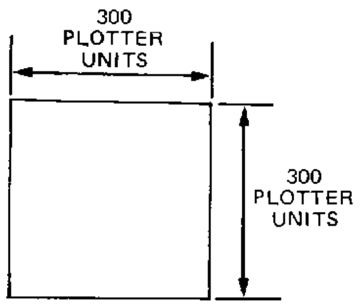

Figure 6-10. Incremental Draw Box

Rotating 45°

To rotate the box counterclockwise by 45° proceed as follows:

Procedure	Send	w	ROTATE instruction.
		b	Incremental rotate angle parameter for 45° (MBA format).
		s	INCREMENTAL DRAW instruction.
		@ @) ,	First move
		I L SPACE SPACE	Second move
		@ @ 6 4	Third move
		V T SPACE SPACE	Fourth move
		|	Terminator.

Result Draws a four sided box rotated 45° counterclockwise from previously plotted box (see Figure 6-11). The plot is shown in Detail D, Figure 6-22.

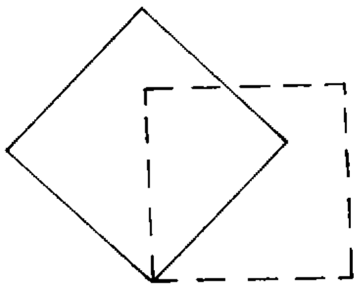

Figure 6-11. Box Rotated 45°

Rotating Labels

By leaving the ROTATE instruction at 45° and invoking LABEL MODE ON, the character strings will be plotted at a 45° angle. To demonstrate this, use the front panel controls to position the pen about an inch to the left of the upper left hand side of the last drawn box and proceed as follows:

Procedure	Send ~ '		LABEL MODE ON instruction.
	Type text, "This is a rotated label"	CR LF	character string.
	Send CNTL C or, ETX		Terminates LABEL MODE ON.

Result Character string consisting of text, "This is a rotated label" is plotted at a 45° angle (see Detail D, Figure 6-22).

Rotating Arcs And Circles

The effect of the ROTATE instruction on arcs and circles is shown next. A circle is plotted with the point of origin at zero degrees then, four more circles each incremented 90° are drawn. Notice that each 90° angle specified is added to the angle of rotation currently in effect.

Procedure Send w	ROTATE instruction. As no parameter is specified, rotate angle is set to zero degrees.
t	ARC CLOCKWISE instruction.
d @	Radius parameter, 256 plotter units (MBN format).
w d	Rotate 90° (MBA format).
t	ARC CLOCKWISE using last radius parameter.
w d	Rotate 90° (Cumulative angle equals 180°).
t	ARC CLOCKWISE using last radius parameter.
w d	Rotate 90° (Cumulative angle equals 270°).
t	ARC CLOCKWISE using last radius parameter.
w d	Rotate 90° (Cumulative angle equals 360°/0°).
t	ARC CLOCKWISE using last radius parameter.
}	Terminator.

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Result See Figure 6-12 and Detail E, Figure 6-22.

1. Draws circle #1 with the point of origin at 0°.

2. Draws circle #2 with the point of origin rotated to 90°.

3. Draws circle #3, the point of origin has again been rotated 90° to make a cumulative rotation angle of 90° + 90° = 180° = point of origin.

4. Draws circle #4, the point of origin has been rotated another 90° which is added to the previous rotate angle, 180° + 90° = 270° = point of origin.

5. Draws circle #5 which is really a retrace of circle #1 and brings the point of origin back to 0°. A rotation of 90° has been added to the cumulative rotate angle of 270° to 360° or, 0°.

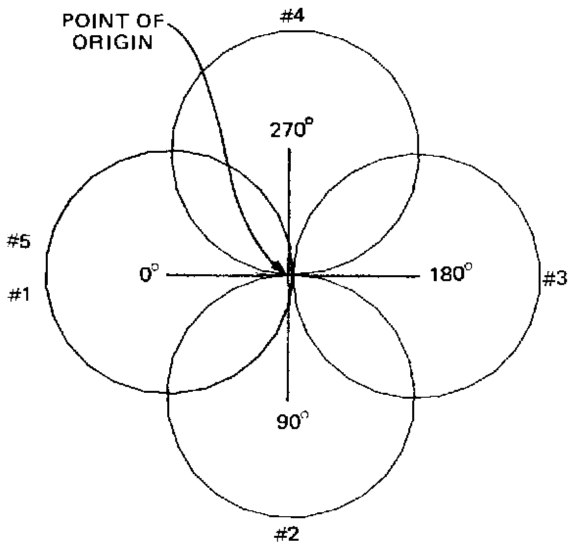


Figure 6-12. Circle Rotation

Rotate At Last Angle

This instruction is similar to the ROTATE instruction, except the angle of rotation is established equal to the last angle plotted (excluding front-panel moves) instead of being added to the previous value of the angle. ROTATE AT LAST ANGLE has no parameter.

To demonstrate the Rotate at Last Angle instruction, four vectors are drawn, using the INCREMENTAL DRAW instructions. The last three vectors are rotated by the angle of the first vector to form an arrowhead at the tip.

Procedure Send

s	INCREMENTAL DRAW instruction.	
V T , SPACE	First move	
x	ROTATE AT LAST ANGLE instruction.	
s	INCREMENTAL DRAW instruction.	
^ N SPACE 9	Second move	
s	INCREMENTAL DRAW instruction.	
@ @ > .	Third move	
s	INCREMENTAL DRAW instruction.	
A R SPACE 9	Fourth move	
}	Terminator.	

NOTE

The terminator } does not take the plotter out of the ROTATE AT LAST ANGLE mode. To restore the plotter to its default rotate angle of zero degrees, send the ROTATE instruction w without specifying an angle. See ROTATE instruction.

Result Draws an arrow using four vectors with the last three vectors being rotated by the angle of the first vector. The co-ordinate values of the last three vectors, in plotter units, are -50,25; 0,-50 and 50,25. (See Detail F, Figure 6-22.)

Fixed Dash Line Plotting

The FIXED DASH LINE instruction enables all absolute and incremental vectors and arcs to be plotted in a specified dash line font, except the incremental vectors generated for label characters. As an arc is approximated by a series of chords, each chord is considered as a vector in dash line plotting.

The three parameters that must be specified in this instruction are:

a. Dash lengths in relative units.

b. Space lengths in relative units.

c. Pattern length in plotter units.

To define these parameters and units, consider that a dash line pattern, 200 plotter units in length, is to be plotted using the dash line font shown in Figure 6-13. Relative units refer to the ratios between dash and space lengths. Relative unit parameters are encoded in sequence, from left to right, in accordance with the modified SBN format.

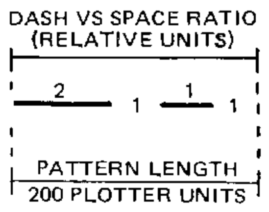


Figure 6-13. Dash Line Font Example

The line font is made up of a 2 unit dash, a 1 unit space, a 1 unit dash and a 1 unit space pattern sequence to be repeated in 200 plotter unit intervals as shown in Figure 6-14.

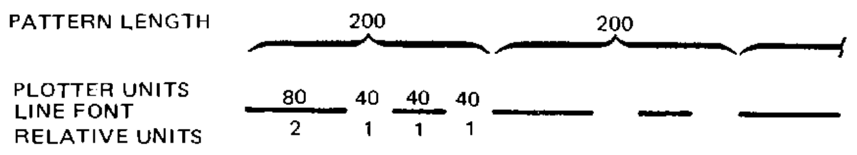


Figure 6-14. Dash and Space Unit Values

To demonstrate the dash line feature both a box and a circle will be plotted in dash line font.

In the examples only two dashes and two spaces are specified in the line font. Actually, up to 8 dashes and 8 spaces, each one from 0 to 31 relative units long, can be specified. A dash with length specified = 0 relative units defines a dot in the pattern.

Drawing A Fixed Dash Square

To draw a dash square, proceed as follows:

Procedure	Send	~ Q	FIXED DASH LINE instruction.
		"	Two unit dash.
		A	One unit space.
		!	One unit dash.
		A	One unit space.
		c H	Pattern length 200 plotter units (MBN format).

(Two unit dash, one unit space, one unit dash, one unit space: MODIFIED SBN** FORMAT)

The above procedure invokes a dash line mode with a fixed pattern length.

**The Single Byte Number (SBN) format covers the range of integers from 0 – 63; however, only 0 – 31 is used in specifying dash line font parameters. Dash length parameters are defined by making binary bit #6 (32_{10}) true (1). The binary format for dashes and spaces thus becomes;

Dash Length	0	1	D	D	D	D	D
Space Length	1	0	S	S	S	S	S

Send	s	INCREMENTAL DRAW instruction.	
	@ @) ,	First move	↑
	I L SPACE SPACE	Second move	→
	@ @ 6 4	Third move	↓
	V T SPACE SPACE	Fourth move	←
	|	Terminator.	

Result Draws a four sided box, each side being 300 plotter units in length in dash line font (see Figure 6-15). The plot is shown in Detail G, Figure 6-22. This is the box, drawn in solid line format, in the ROTATE instruction example. Verify that there are 1-1/2 pattern lengths in each side of the box.

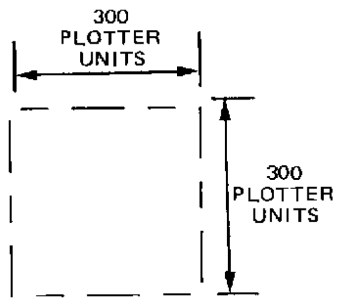


Figure 6-15. Fixed Dash Line Square

Drawing A Fixed Dash Circle

To illustrate dash circle two circles are drawn using dash line font. The first circle has a "worst case" arc tolerance resulting in one chord being drawn every 45°. The second circle has the default "best case" arc tolerance.

Procedure	Send	~ T	ARC TOLERANCE instruction.
		?	Arc tolerance, 63 plotter units.
		t	ARC CLOCKWISE instruction.
		f P	Radius parameter, 400 plotter units (MBN format).
		}	Terminator.

Result Draws a circle, approximated by eight chords, in dash line font (see Figure 6-16). The dash line font is the one previously defined in the procedure for Figure 6-15. The plot is shown in Detail J, Figure 6-22.

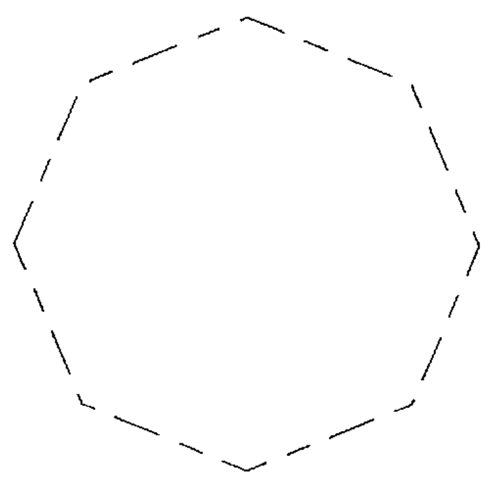


Figure 6-16. Fixed Dash Line Circle With 63 Plotter Units Arc Tolerance

Procedure	Send ~ T	ARC TOLERANCE instruction. Without a parameter, tolerance is set to default value (1 plotter unit).
	t	ARC CLOCKWISE instruction. Uses last radius received when no new radius parameter is sent.
	}	Terminator.

Result Draws a circle in dash line font having a radius of 400 plotter units (see Figure 6-17). The plot is shown in Detail J, Figure 6-22.

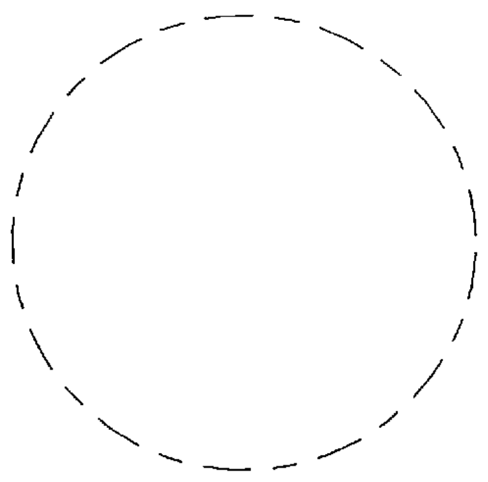


Figure 6-17. Fixed Dash Line Circle With 1 Plotter Unit Arc Tolerance

Variable Dash Line Plotting

The VARIABLE DASH LINE instruction is similar to the FIXED DASH LINE instruction except, as its name implies, the pattern length is varied so that whole pattern lengths fit within each plotted vector. If the vector is shorter than the specified pattern length, one complete pattern length is adjusted to fit between the end points of the vector.

Again, each chord of an approximated arc is considered as a vector so, an integer number of dash pattern lengths will be drawn in each chord.

After a Variable Dash Line instruction is received, the plotter looks at each of the following absolute vectors, incremental vector and arc parameters to be drawn and adjusts the pattern length on a vector-by-vector basis, so that an integer number of patterns will fit into the vector.

To illustrate the variable dash line plot and allow an easy comparison to the fixed dash line plot, similar box and circle plots are made.

Drawing A Variable Dash Line Square

Procedure Send

~ R	VARIABLE DASH LINE instruction.
$	Four unit dash
B	Two unit space
"	Two unit dash
B	Two unit space
$	Four unit dash
c H	Pattern length, 200 plotter units (MBN format).

The above procedure invokes a dash line mode with a variable pattern length.

Send

s	INCREMENTAL DRAW instruction.
@ @) ,	First move ↑
J L SPACE SPACE	Second move →
@ @ 6 4	Third move ↓
V T SPACE SPACE	Fourth move ←
}	Terminator.

Result Draws a four sided box, each side being 300 plotter units in length in variable dash line font. Note that there are two complete pattern lengths in each side of the box. Note also, that the pattern specified starts and stops with a dash which provide a wrap-around effect at the vertices (see Figure 6-18). The plot is shown in Detail H, Figure 6-22.

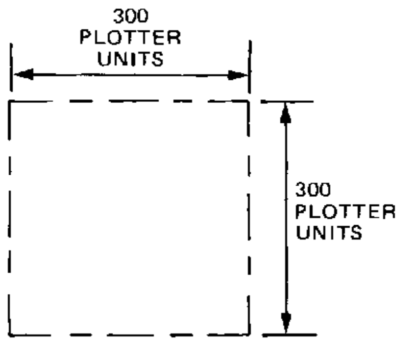


Figure 6-18. Variable Dash Line Square

Drawing Variable Dash Line Circles

Two circles are plotted next while in the variable dash line mode, then compared with the similar circles previously plotted using fixed dash lines.

Procedure	Send	~ T	ARC TOLERANCE instruction.
		?	Arc Tolerance, 63 plotter units.
		t	ARC CLOCKWISE instruction (using last radius parameter received).
		}	Terminator.

Result Draws a circle, approximated by eight chords, in variable dash line font (see Figures 6-19 and 6-22, Detail K).

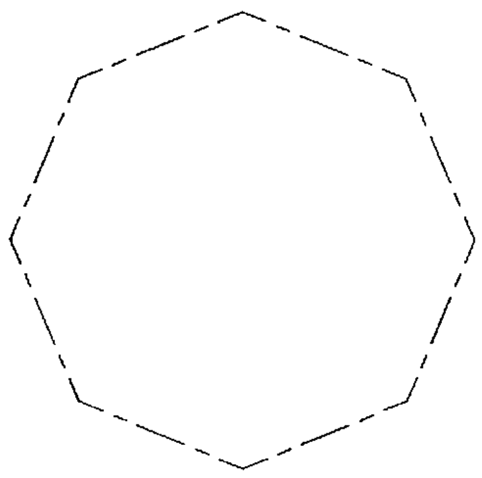


Figure 6-19. Variable Dash Line Circle With 63 Plotter Units Arc Tolerance

Procedure Send ~ T — ARC TOLERANCE instruction. Without a tolerance parameter plotter goes to default tolerance of 1 plotter unit.

t — ARC CLOCKWISE instruction (using last radius parameter received).

} — Terminator.

Result Draws a circle in variable dash line font, having a radius of 400 plotter units. See Figures 6-20 and 6-22, Detail K.

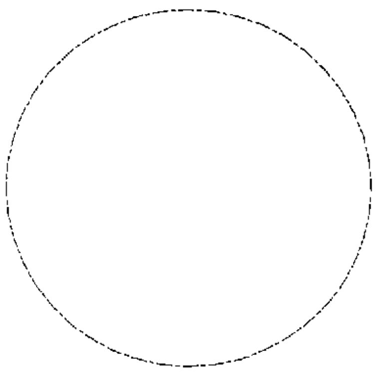


Figure 6-20. Variable Dash Line Circle With 1 Plotter Unit Arc Tolerance

A careful examination of the last two circle plots will show that each chord in the "worst case" arc tolerance circle contains two complete pattern lengths. The best (default) arc tolerance circle shows at least one pattern length squeezed into each chord.

Terminating The Dash Line Mode

To restore solid line plotting, send the FIXED DASH LINE instruction, (~) (Q) without any font or pattern length parameters. To verify the plotter is out of the FIXED DASH LINE mode and, that the last radius parameter received can be used, draw a solid line circle.

Procedure	Send (~) (Q)	FIXED DASH LINE instruction. Reverts to default solid line plotting when font and pattern length parameters are omitted.
	(t)	ARC CLOCKWISE instruction, using last radius parameter received.
	(})	Terminator.

Result Draws a solid line circle having a radius of 400 plotter units (see Figure 6-21). The plot is shown in Detail I, Figure 6-22.

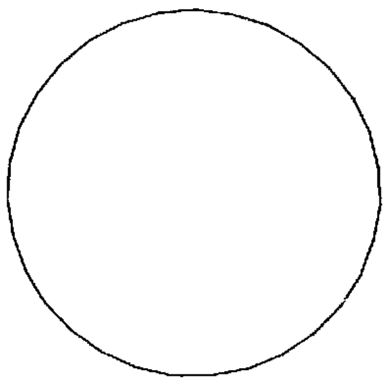
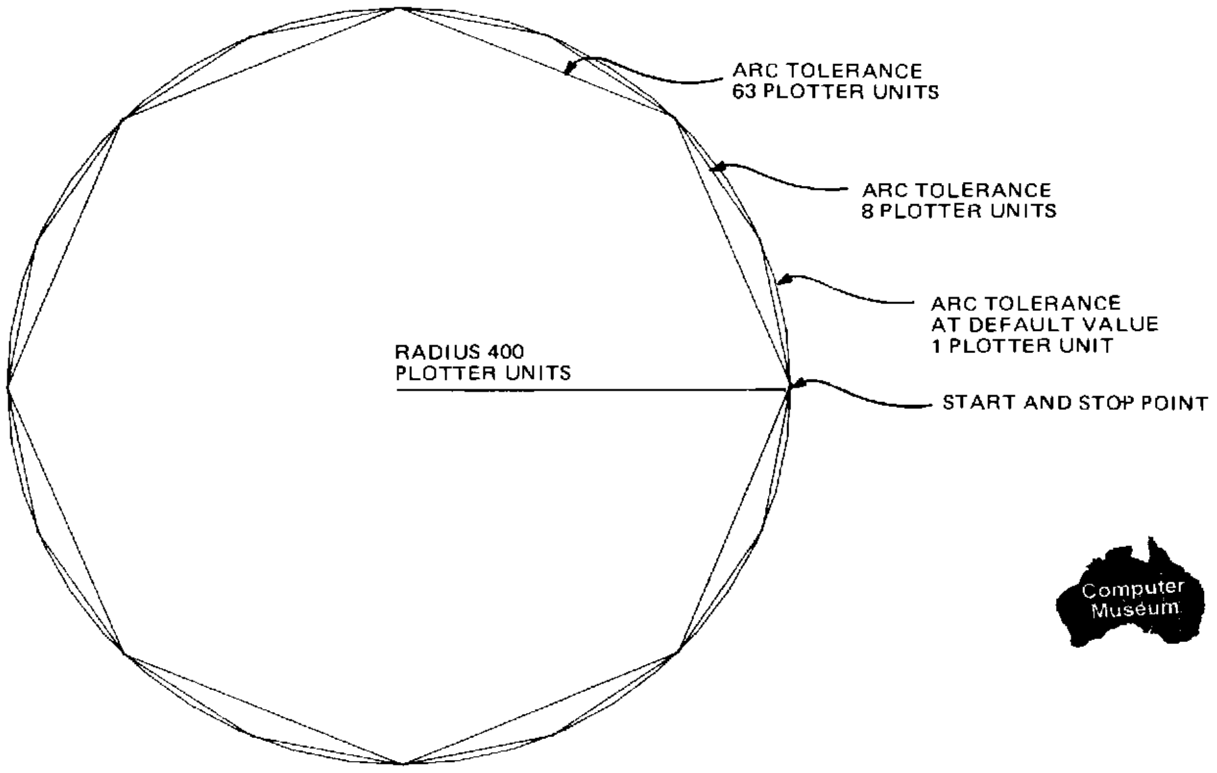


Figure 6-21. Solid Line Circle

ARC TOLERANCE DEVIATIONS
DETAIL "C"



ROTATE INSTRUCTION
DETAIL "D"

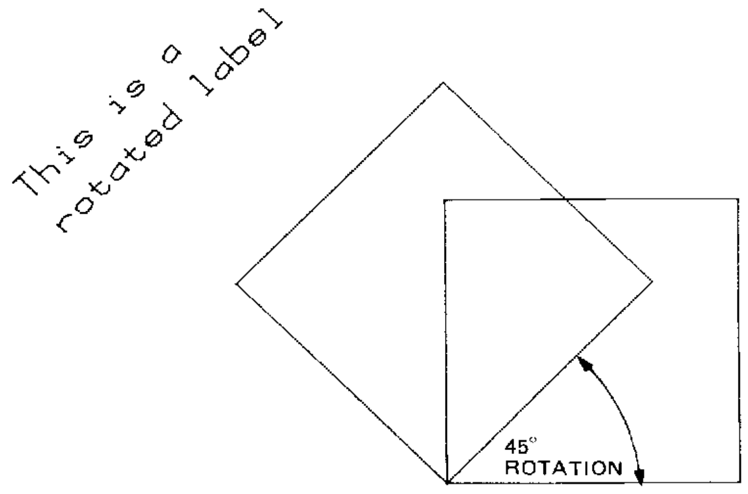
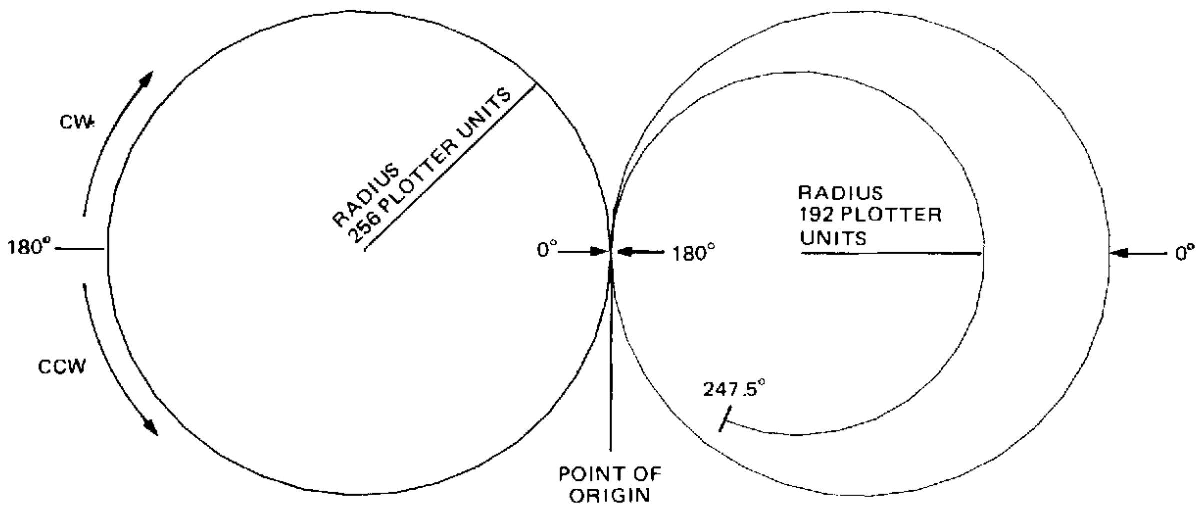


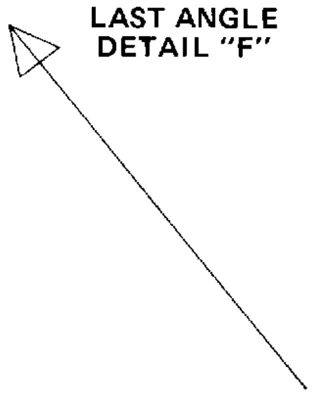
Figure 6-22. Extended Graphic Instructions Sample Program Plots
(Page 1 of 2)

CIRCLES AND ARCS

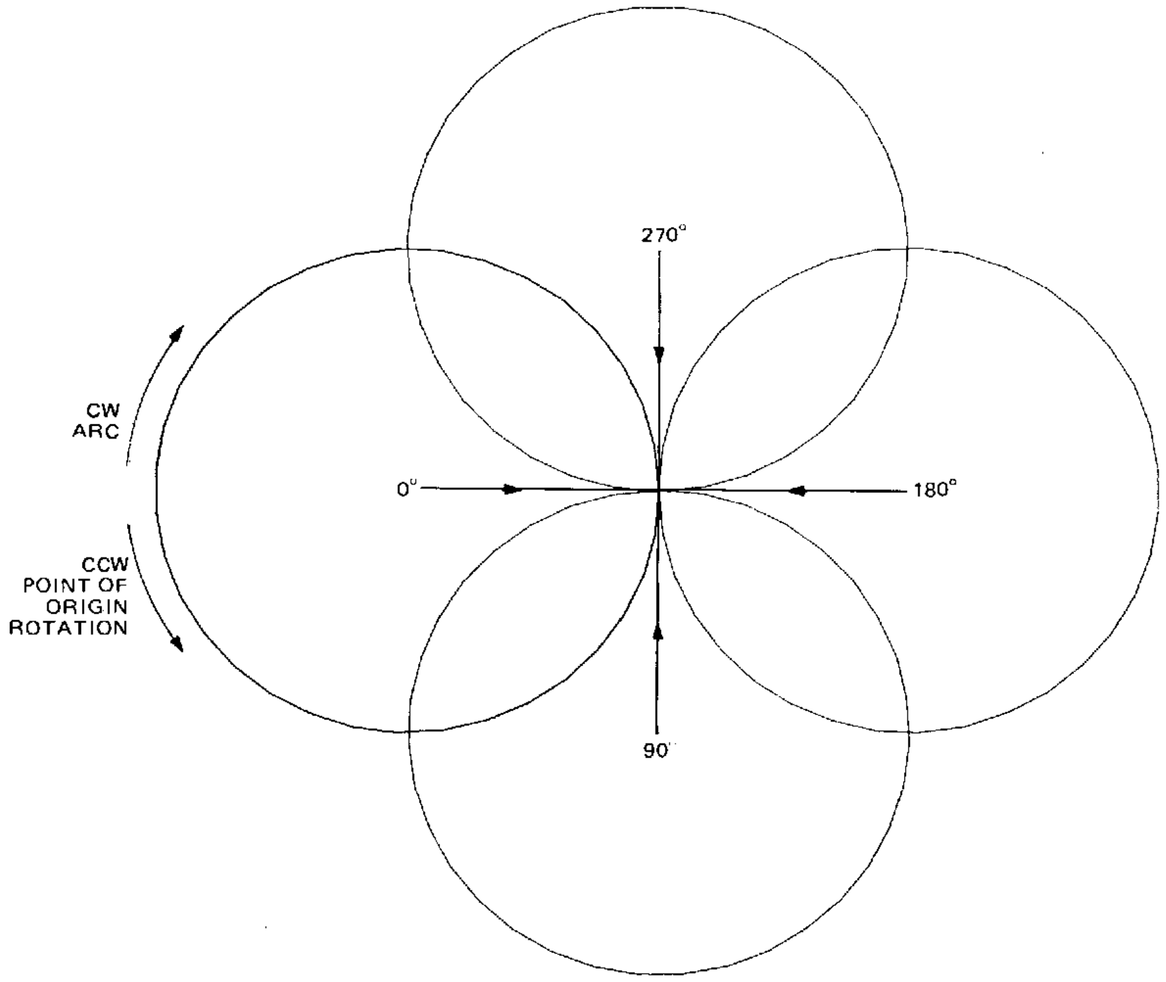
DETAIL "A" DETAIL "B"



ROTATE AT
LAST ANGLE
DETAIL "F"



CIRCLE ROTATION
DETAIL "E"



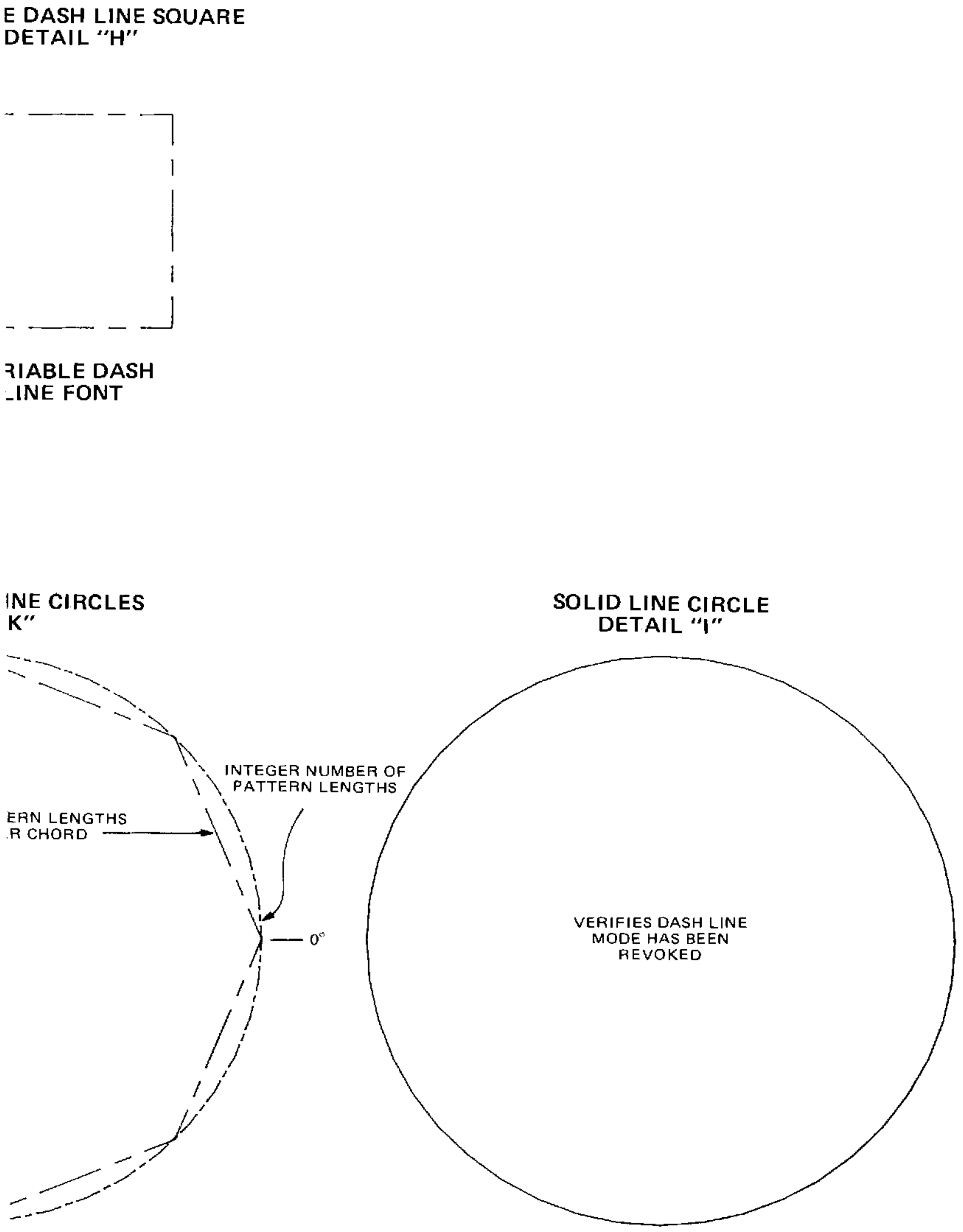
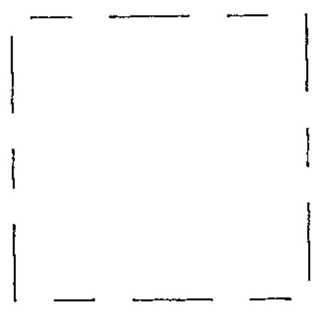


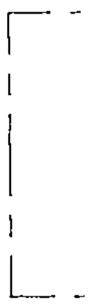
Figure 6-22. Extended Graphic Instructions Sample Program Plots
(Page 2 of 2)

FIXED DASH LINE SQUARE
DETAIL "G"



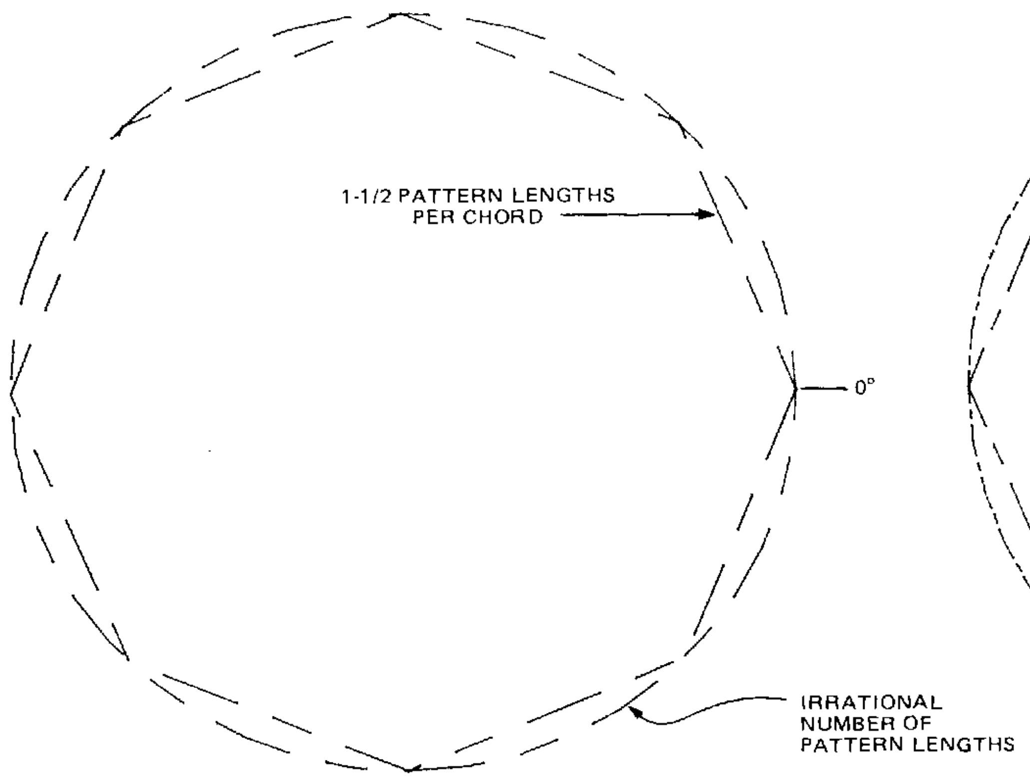
FIXED DASH
LINE FONT

VARIABL

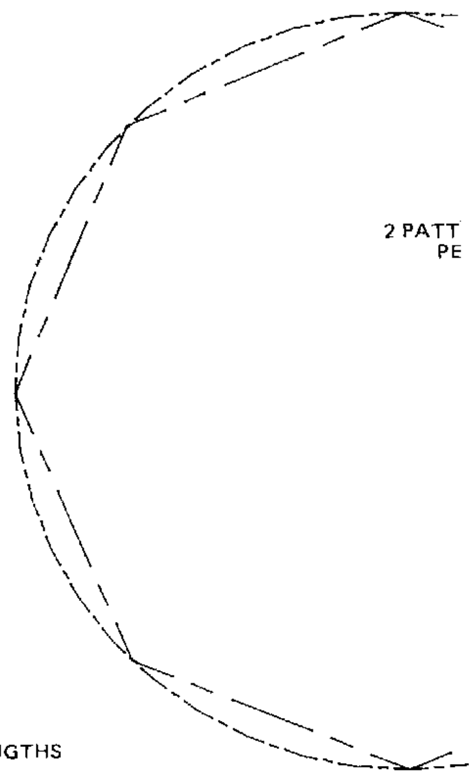


VAI

FIXED DASH LINE CIRCLES
DETAIL "J"



VARIABLE DASH LI
DETAIL "



Chapter 7
Macro Instructions

Introduction

This chapter includes the following discussions:

- The Macro Define/Macro Terminate Instructions
- Defining Macros
- Invoking Macros
- Erasing Macros
- Automatic Macros

During plotting many repetitive operations are required. Examples of typical repetitive operations are the setting of graph limits, grid size, dash line font and labeling.

In order to minimize data transmission, which is especially desirable in timeshare systems, the plotter provides internal storage of data for use in repetitive operations. These internally stored data strings are called Macro Instructions and hereinafter referred to as Macros.

A Macro is simply a "copy of input graphic instructions". This "copy" (Macro) can be inserted into the stream of graphic instructions using a minimum number of bytes to provide a repeated execution of graphic plots.

Up to 64 user defined macros can be stored in the Plotter's Read/Write Memory (RAM) which has a capacity of 1128 eight-bit data bytes. An additional 2048 bytes of RAM is available as an option. The entire RAM capacity, less 100 bytes, can be used for storing macros.

The RAM also provides input buffer space for incoming graphic instructions. As macros are defined, this input buffer space is reduced. A macro requires space for the total number of bytes in the macro, plus one. At any time the input buffer can be interrogated to determine the remaining buffer size.

If the user attempts to overflow the buffer with macros, the ERROR lamp will light indicating a Macro Error Type 18. (Refer to Output Error Types in Chapter 1.) Note, that with any macro error, the macro in question is both ignored and erased.

The Macro Define/Macro Terminate Instructions

To define a macro use the following format:

Send	~ *	MACRO DEFINE instruction.
	A	This is a user assigned identification number, in this example A indicates macro #1, using the SBN format.

Next, send the plot data string for the desired graphic instructions. If the data string includes a LABEL MODE ON instruction, the label terminator also must be included before the macro is terminated. To terminate a macro:

Send	z	Macro Terminator.

Defining Macros

Once a macro define instruction with its identifying number has been sent, the previous definition with this identifying number is automatically erased.

Three macros are defined below. The first draws the label "HP" once. The second macro invokes the first macro two times to produce the repeated labeling "HP HP". The third macro invokes the second macro two times to produce, "HP HP HP HP". These macros demonstrate how one macro can be used to invoke other macros. Note, that a macro cannot invoke itself.

Procedure	~ *	MACRO DEFINE instruction.
	A	Store macro under the identifying number 1 (SBN).
	~ '	LABEL MODE instruction.
	H P SPACE	Enters the label string "HP".
	ETX	Terminates the Label mode.
	z	Macro Terminator.

Position the pen to a clear area on the chart paper. To verify that the macro has been sent and received correctly, invoke the macro by sending, { A and check that the plotter prints, "HP".

Continue with the other two macros:

Procedure	Send	~ *	MACRO DEFINE instruction.
		B	Store macro under identifying number 2 (SBN format).
		{ A { A	Invokes the macro stored under the identifying number, "1" two times (SBN format).
		z	Macro Terminator.
		~ *	MACRO DEFINE instruction.
		C	Store macro under identifying number 3 (SBN format).
		{ B { B	Invokes the macro stored under the identifying number "2" two times (SBN format).
		z	Macro Terminator.

Invoking Macros

Having defined macros 1, 2 and 3 each macro is then invoked in turn.

Procedure	Send	{ A	Invoke Macro 1.
		{ B	Invoke Macro 2.
		{ C	Invoke Macro 3.

Result Plotter executes the graphic instructions stored as macros under identifying numbers 1, 2 and 3.

Macro 1 causes the label "HP" to be plotted.

Macro 2 causes Macro 1 to be invoked twice printing "HP HP".

Macro 3 causes Macro 2 to be invoked twice printing "HP HP HP HP".

Remember that the Plug-in ROM is used for pre-defined macros but the user defined macros in RAM supersede them.

Erasing Macros

An individual macro can be erased by defining a null macro. For example, assume Macro #2 is to be erased, then the instruction is:

Procedure	Send	~ *	MACRO DEFINE instruction.
		B	Accesses macro stored at 2 (SBN format).
		z	Macro Terminator.

Result Defining a macro with no plot data, effectively erases it. Attempts to invoke an erased macro will cause the ERROR lamp to light indicating a Missing Macro Error.

To erase all macros stored in RAM, perform the following:

Procedure	Send	~ *	MACRO DEFINE instruction (with no macro number).
		z	Macro Terminator.

Result Causes all user defined macros stored in the Plotter's Read/Write Memory to be erased.

Automatic Macros

Quite often it is desirable to have an identifying symbol, such as an asterisk or an arrowhead plotted at the completion of each vector or arc.

The desired identifying symbol is stored as a macro in the format previously described in this chapter. When the AUTOMATIC MACRO instruction is sent, the specified macro is automatically invoked upon completion of each vector or arc. Once invoked, the AUTOMATIC MACRO mode remains in effect until it is properly terminated.

Invoking Automatic Macros

Assume a centered symbol from Character Set #5 is to be added to each vector or arc. First, the macro is loaded as follows:

Procedure Send	~ *	MACRO DEFINE instruction.
	C	Store macro under identifying number "3" (SBN format).
	~ P	LABEL FONT instruction.
	b SPACE	Designate Character Set #5 as the standard font.
	~ '	LABEL MODE ON instruction.
	SI	Select standard font.
	B	Enters desired symbol as label string.
	ETX	Terminates the Label Mode.
	z	Macro Terminator.

With the macro loaded, the AUTOMATIC MACRO instruction causes the macro to be automatically invoked upon completion of each arc and vector in the same plot as follows. See Figure 7-1.

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Procedure	Send	~ #	AUTOMATIC MACRO instruction.
		C	Causes the specified MACRO to be automatically invoked upon completion of each arc and vector plot.
		s	INCREMENTAL DRAW instruction.
		F H & (	First move (PMB format).
		F H 9 8	Second move (PMB format).
		Y X 9 8	Third move (PMB format).
		Y X & (	Fourth move (PMB format).
		t	ARC CLOCKWISE instruction.
		d @ ` h	Radius 256 plotter units, Start Angle 0°, Stop Angle 180°.
		u	ARC COUNTERCLOCKWISE instruction.
		d @ ` h	Radius 256 plotter units, Start Angle 0°, Stop Angle 180°.
		}	NOP Delimiter.

Result Draws the pattern illustrated in Figure 7-1. Upon completion of each individual vector, or arc, the macro is automatically invoked to plot the six centered symbols.

NOTE

In the preceding exercise, the character set invoked by the macro is used to produce a special centered symbol at the end of each vector or arc. The user should be aware that this same character set remains selected for Label Mode operations after the Macro has been executed, unless another LABEL FONT instruction is executed. In general, any graphic specifications invoked within a macro, automatic or otherwise, are not exclusive to the macro but remain in effect upon termination of the macro.

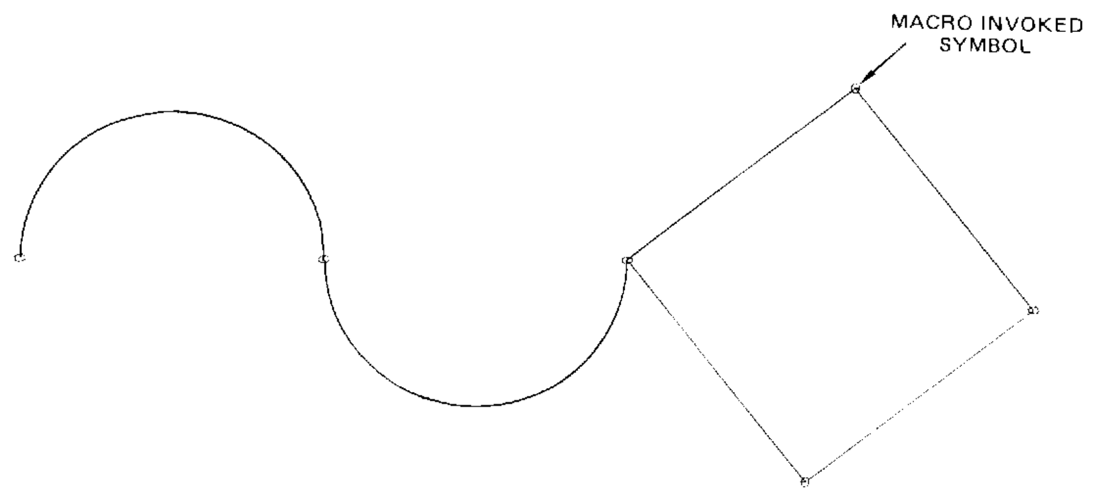


Figure 7-1. Automatic Macro Plot

Terminating Automatic Macros

As stated earlier, once invoked an automatic macro remains effective until it is terminated. To terminate an automatic macro, the AUTOMATIC MACRO instruction is sent without an identifying number.

Procedure	Send ~ #	AUTOMATIC MACRO instruction.
	}	Terminator.
Result	AUTOMATIC MACRO mode is terminated.	

Chapter 8

Input/Output Operations

Introduction

Device control instructions in the Input/Output (I/O) group provide the plotter with the flexibility required to operate in a wide variety of data communication systems. Basically, the Host Computer transmits data to the plotter while monitoring the plotter's status to ensure the plotter receives the data and responds in the proper sequence.

NOTE

All Device Control Instructions start with the ESC . sequence, and are processed as soon as they are received by the plotter. They are not stored in the plotters' graphic data buffer.

The individual I/O control instructions are described in this chapter in the following order:

- **Set Output Mode**
- **Output Graphic Limits**
- **Set Output Mode (Default State)**
- **Output Current Position**
- **Output Digitized Point**
- **Abort Device Control Instructions**
- **Output Identification**
- **Output Status**
- **Output Buffer Size**
- **Output Buffer Space**
- **Output Error**
- **Set Handshake Mode**
- **Set Extended Output and Handshake Mode**
- **Set Plotter Configuration**
- ** **Output Extended Status**

---

*NOTE

This instruction pertains primarily to the 7221S plotter and is relevant to the 7221B only to indicate that the paper advance option is "off" (not pertinent).

Set Output Mode

The SET OUTPUT MODE instruction determines the way the plotter will respond to output requests and handshake protocol and, is typically formatted as follows:

NOTE

Refer to Chapter 10 for the definition of (DEC) and (ASC) formats.

ESC . M	SET OUTPUT MODE instruction.
2 Ø Ø	Turn-around time in milliseconds from 0 to 9999, 0 to 4 digits decimal (DEC) format, is the delay between an output request and the start of the transmission. When not specified, the default value is 0 milliseconds.
;	Delimiter.
1 7	Output trigger character (ASC format) typically Device Control One (DC1). This delays plotter response transmissions until the specified trigger character is received. Default value is 0 causing an immediate output response with no trigger character required.
;	Delimiter.

1 Ø	Echo terminate character (ASC format) typically Line Feed (LF). When specified, causes input that would otherwise be interpreted as graphic data to be discarded from the time that an output starts until this character is received. Default value is 0 resulting in no echo bypass function or character.
;	Delimiter.
1 3	Plotter output terminator (ASC format), with one or two bytes; typically Carriage Return (CR). When specified, follows all responses to output instructions. Default character is Carriage Return.
:	Control Instruction Terminator.

To illustrate the foregoing, the typical format given is entered into the plotter; then, an output request is sent with the specified trigger.

Assuming the plotter has been initialized, the pen is not out of limits and the plotter is connected to a terminal, proceed as follows:

Procedure	Send ESC . M	SET OUTPUT MODE instruction.
	2 Ø Ø	Turn around time, two hundred milliseconds (DEC format).
	;	Delimiter.
	1 7	Output Trigger Characters (ASC format-DC1).

;	Delimiter.
1 Ø	Echo Terminate-LF (ASC format).
;	Delimiter.
1 3	Output Terminator-CR (ASC format).
:	Control Instruction Terminator.

Next, a request is sent to the plotter to output its graphic limits.

Send ESC . G	OUTPUT GRAPHIC LIMITS instruction.

Note that nothing happens, the plotter is now waiting for the trigger character, and all graphic instructions are ignored.

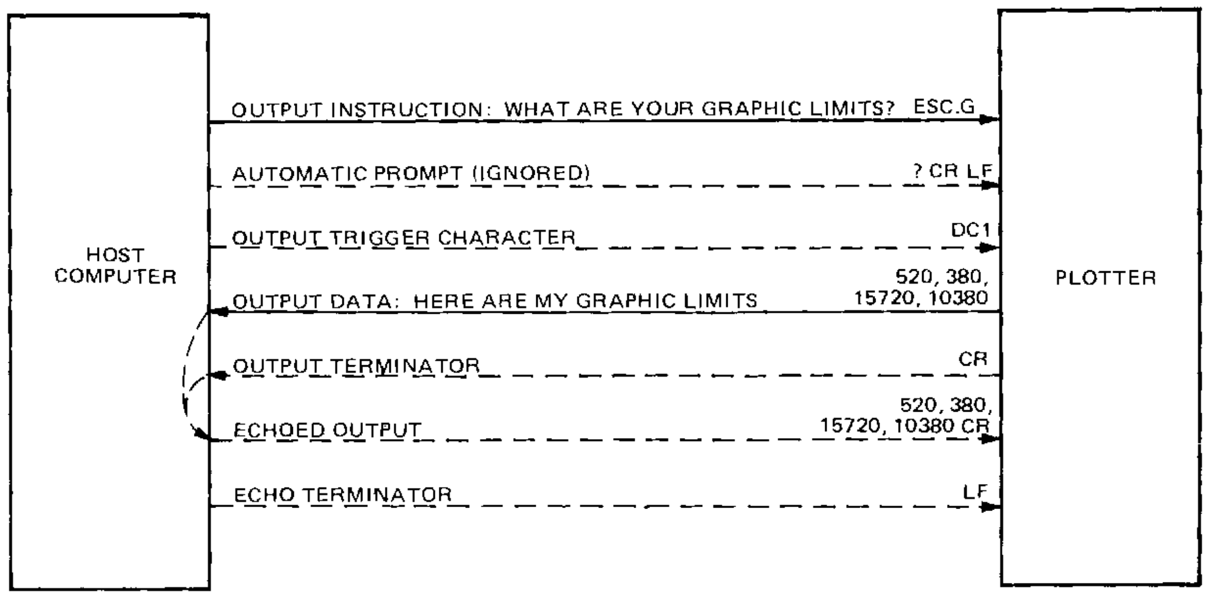
Send CNTL Q	Output Trigger Character-DC1.

NOTE

CONTROL and Q keys must be pressed simultaneously to send DC1. Keys for DC1 may vary from terminal to terminal.

Result Having received the trigger character, the turn-around time delay is initiated and, after the specified two hundred millisecond delay, the plotter outputs the Graphic Limit parameters followed by a Carriage Return. The Echo Terminator (Line Feed) when received, causes the plotter to resume receiving input data into its buffer.

An example of an output sequence is illustrated in Figure 8-1, with the dash lines indicating optional events.



Events :

1. Plotter receives the output instruction.

2. Host computer sends automatic prompt which is ignored by plotter until trigger character is received. If no trigger character is specified, no suppression occurs.

3. Plotter receives trigger character and starts turn-around delay. If a trigger character is not specified, then turn-around delay starts immediately after receipt of output instruction.

4. After turn-around delay, if any, and when plotter is prepared to send, its output begins at the selected transfer rate, with commas as delimiters.

5. Plotter outputs one, or two output terminator bytes, if specified.

6. Plotter suppresses input when output starts until echo terminator is received. If no echo terminator is specified, then there is no suppression.

7. Upon receipt of the echo terminator the plotter resumes receiving input into its buffer.

Figure 8-1. Typical Plotter Output Sequence

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Output Graphic Limits

The OUTPUT GRAPHIC LIMITS instruction causes the plotter to transmit the location of its current lower left and upper right graphic limits in machine units. The manner in which the plotter responds to this instruction is defined by the SET OUTPUT MODE instruction, which was set in the previous procedure.

Procedure Send the OUTPUT GRAPHIC LIMITS instruction, the Output Trigger character and the Echo Terminator character shown in the previous example.

Result The plotter, after a turnaround time of two hundred milliseconds, transmits the following output data.

520, 380, 15720, 10380

The first XY pair 520, (X) 380, (Y) are the coordinates of the lower left graphic limit. The second XY pair 15720 (X) 10380 (Y) are the coordinates of the upper right graphic limit.

Note that the graphic limit parameters are unsigned numbers and that each number can be from one to five digits long.

Set Output Mode (Default State)

As stated earlier, the plotter responds to output requests according to the SET OUTPUT MODE instruction. To further demonstrate this, the SET OUTPUT MODE is returned to its default status, then, the output request for the plotter to output its current position is sent.

Procedure	Send ESC . M	SET OUTPUT MODE instruction.
	:	Terminator.

Result The output mode is set to its default condition. This state includes:

Zero turn-around delay.

Immediate output response with no trigger character required.

No echo bypass function or character.

A Carriage Return output terminator.

Output Current Position

The OUTPUT CURRENT POSITION instruction requests the plotter to transmit its physical pen position as an XY point in machine units, (see Figure 8-2) and its pen status. If the pen is moving at the time the output request is received, the current position is defined as the endpoint of the vector being plotted. Since the OUTPUT CURRENT POSITION instruction is a device control instruction and is not stored in the buffer, the current position coordinates transmitted are those which exist when the OUTPUT CURRENT POSITION instruction is received, regardless of how much unexecuted graphic data remains in the plotter's buffer.

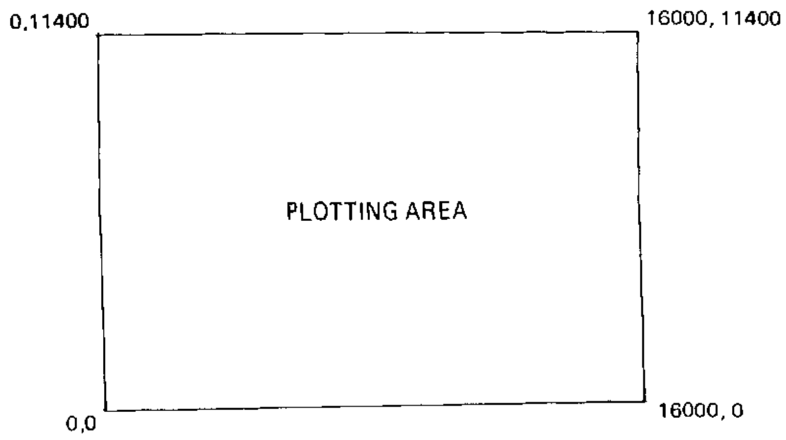

Figure 8-2. Plotting Area In Machine Units

With the SET OUTPUT MODE in the default state and, with the pen positioned at the center of the plotting area, the OUTPUT CURRENT POSITION instruction is sent as follows:

Procedure	Send ESC . M	SET OUTPUT MODE instruction.
	; ; 1 Ø ; :	Sets default values for turn-around time, output trigger character and output terminator. Sets Line Feed as an echo terminate character.
	Send ESC . C	OUTPUT CURRENT POSITION instruction.

Result Plotter transmits current position. If the pen is centered, the transmitted XY data is:

8000, 5700, 0

Note that the X (8000) and Y (5700) values are unsigned numbers and that each number can be from one to five digits long (leading zeroes are suppressed). The pen status is indicated by the third parameter: a zero if the pen is up, and a 1 if the pen is down.

Output Digitized Point

The OUTPUT DIGITIZED POINT instruction causes the plotter to stop executing graphic instructions upon completion of the current instruction, and to transmit the graphic position with the status and number of the pen in use.

The major differences between this instruction and the OUTPUT CURRENT POSITION instruction is:

1. Waits for operator to operate ENTER switch.
2. The instruction sends the point in plotter units (see Figure 8-3).
3. The instruction also sends the number of the pen currently loaded in the pen holder.

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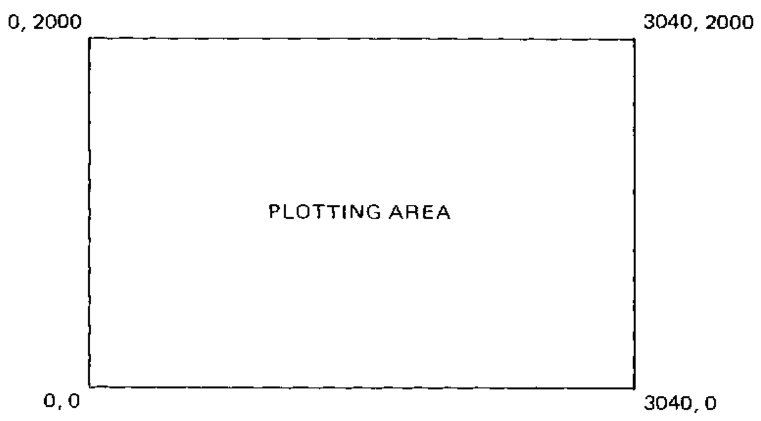

Figure 8-3. Plotting Area In Plotter Units (Default State)

Upon receipt of the OUTPUT DIGITIZED POINT instruction, the front-panel ENTER lamp is turned ON steady and the plotter suspends execution of graphic instructions after completion of the instruction currently being plotted. The plotter will remain in this suspended plotting state until either the ENTER pushbutton is operated or an ABORT DEVICE CONTROL instruction is received.

Pushing the ENTER pushbutton switch causes the lamp to turn OFF, the digitized point to be transmitted, and the plotter to resume executing graphic instructions. The transmission is made according to the conditions set-up in the SET OUTPUT MODE instruction.

Procedure Send ESC . D — OUTPUT DIGITIZED POINT instruction.

Result Front panel ENTER lamp is turned on steady.

Procedure Using the front panel controls, position the pen at the approximate center of the plotting area. Select pen #4 and push the ENTER pushbutton down.

Result ENTER lamp is turned OFF. Plotter transmits digitized data in the following format:

1496, 1064, 0, 4

The current graphic position is given in plotter units: X=1496 and Y=1064. The 0 signifies the pen is in the up position (a 1 here would signify the pen was down) and the last parameter 4 signifies that pen #4 is loaded in the pen arm.

As stated earlier, after receiving an OUTPUT DIGITIZED POINT instruction the plotter goes into a suspended plotting state which can only be changed by pressing the ENTER pushbutton or, aborting the output request which is discussed in the following paragraph.

NOTE

Pressing the ENTER pushbutton is ignored if the OUT OF LIMIT indicator is on (i.e., cannot digitize a point which is beyond the Graphic Limits).

Abort Device Control Instructions

This instruction can be used to clear an OUTPUT DIGITIZED POINT instruction, or other Device Control instructions. Upon receiving this abort instruction, the plotter ENTER lamp is turned off, the pending output is aborted (not transmitted) and the plotter resumes execution of graphic instructions.

To demonstrate this instruction the plotter is set-up to plot a repetitive circular pattern. While executing the circular plot an OUTPUT DIGITIZED POINT instruction is sent followed by an ABORT DEVICE CONTROL instruction. The following may be done without a pen being loaded in the pen arm.

Procedure Send t — ARC CLOCKWISE instruction.

d @ — Radius parameter (MBA format).

t t t t t — Continue arc plotting n times.

While plotter is plotting arcs;

Send ESC . D — OUTPUT DIGITIZED POINT instruction.

Result Plotter plots a repetitive arc pattern. Upon receipt of the OUTPUT DIGITIZED POINT instruction, the plotter completes its current arc and stops plotting at the zero degree (3 o'clock) point with the ENTER lamp turned on steady.

Procedure Send ESC . J — ABORT DEVICE CONTROL instruction.

Result The plotter front panel ENTER lamp is turned OFF, the pending data point output is aborted and the plotter resumes plotting the arc pattern.

8

Output Identification

Upon receipt of an OUTPUT IDENTIFICATION instruction, the plotter transmits data which identifies its model number, the date code of the firmware installed and the option code of the plug-in ROM, if one is installed.

To demonstrate this instruction:

Procedure Send (ESC) (.) (A) OUTPUT IDENTIFICATION instruction.

Result Plotter response is dependent on the SET OUTPUT MODE instruction. Assuming that the plotter is in default mode, the plotter transmits data in the following format:

7221, 7269, 0

where:

7221 identifies the Model Number of the plotter.

7269 indicates the date of the firmware installed, coded to read month, day and year as follows:

MONTH	DAY	YEAR
7	26	9 (1979)

This parameter can contain 5 digits.

0 indicates the plotter has no plug-in ROM installed. This parameter can also contain up to 5 digits to indicate the option code of any installed plug-in ROM.

Output Status

Upon receipt of the OUTPUT STATUS instruction the plotter transmits encoded information defining the status of the plotter at the time this instruction is received, regardless of how much unexecuted graphic data remains in the plotters' buffer. For a detailed description, refer to the description of the OUTPUT STATUS instruction in Chapter 10. The following is a typical response after the plotter has been initialized, pen 2 selected and the pen moved into the plotting area.

Procedure Send ESC . F OUTPUT STATUS instruction.

Result The plotter transmits a 16-bit status word as a decimal number such as;

6356

Decimal 6356 converted into its binary equivalent yields

0 0 0 1 1 0 0 0 1 1 0 1 0 1 0 0 which decodes as follows:

- Pen is up.
- Pen #2 is in pen arm.
- Pen stalls 1, 3 and 4 are occupied pen stall 2 is empty.
- No pause in graphics to service front panel.
- Logical pen position is in limits.
- A macroinstruction is not being defined.
- A front panel initialize has occurred.
- Data buffer has overflowed or been emptied.
- No transmission errors have been detected.

Refer to Appendix C for a description of the OUTPUT STATUS word.

Output Buffer Size

The OUTPUT BUFFER SIZE instruction is a request to the plotter to output the total number of bytes available for buffering graphic data. This number can vary from 0 to 1128 bytes or, with the additional 2K RAM option, from 0 to 3056 bytes.

NOTE

The numeric value of the plotters' response to this instruction may be limited to a maximum value, if established by the SET PLOTTER CONFIGURATION instruction.

After receiving the OUTPUT BUFFER SIZE instruction, the plotter waits until the buffer is completely empty, then transmits the available buffer space as a four digit number with leading zeroes being suppressed.

A typical response from a plotter with the standard Read/Write Memory is:

Procedure Send ESC . L — OUTPUT BUFFER SIZE instruction.

Result Plotter transmits 1128.

This indicates there are 1128 bytes of buffer space available for graphic data. As 1128 is also the total buffer capacity with the standard 1K RAM, this indicates that no macroinstructions have been stored in RAM.

Output Buffer Space

This instruction requests the plotter to transmit the current number of available bytes remaining in the buffer. The plotter response is a four-digit number as shown in the following example:

NOTE

The numeric value of the plotters' response to this instruction may be limited to a maximum value, if established by the SET PLOTTER CONFIGURATION instruction.

Procedure Send (ESC) (.) (B) OUTPUT BUFFER SPACE instruction.

Result Plotter transmits 1128.

This indicates that there are 1128 bytes presently available to buffer graphic instructions. In this example the total buffer capacity is available (Standard RAM), which means there are no pending graphic instructions and there has been no allocation of Read/Write memory for macroinstructions.

Output Error

Upon receipt of the OUTPUT ERROR instruction, the plotter transmits encoded information representing the error status of the plotter at the time this instruction is received, regardless of how much unexecuted graphic data remains in the plotters' buffer. The error information includes:

a. The most recent error.

b. The instruction, or macroinstruction in which the error occurred.

c. The number of errors since the last OUTPUT ERROR instruction was received.

For a detailed description, refer to the description of the OUTPUT ERROR instruction in Chapter 10. The following example demonstrates the use of this instruction after deliberately mis-keying a MACRO DEFINE instruction sequence.

Procedure Send ~ : Mis-keyed instruction.

Result Error lamp is turned ON steady.

Procedure Send ESC . E OUTPUT ERROR instruction.

Result Error light is turned off and plotter transmits:

2, 58, 1

Referring to Appendix C, this output is decoded as:

2 = Invalid byte received following the ~ in a graphic instruction.

58 = The ASCII decimal equivalent of the invalid byte : .

1 = The number of errors since power on or, since the last OUTPUT ERROR instruction is one.

Set Handshake Mode

The SET HANDSHAKE MODE instruction establishes a procedure that must be followed to permit blocks of graphic instructions to be transferred from the host computer to the input buffer of the plotter.

One of two SET HANDSHAKE MODE instructions can be selected:

MODE 1: In this mode, the plotter transmits its handshake data string in accordance with the conditions specified in the SET OUTPUT MODE instruction.

MODE 2: With the exception of the turn-around delay, the Handshake transmission is independent of the SET OUTPUT MODE instruction.

Refer to Chapter 10 for a detailed description of the two SET HANDSHAKE MODE instructions.

An example SET HANDSHAKE MODE 2 instruction is illustrated in Figure 8-4. As another demonstration of this mode, the plotter is asked to accept two data blocks. The byte size of the first block exceeds the buffer capacity of the plotter, therefore, the plotter will not acknowledge that it has buffer capacity to accommodate this block. The byte size of the second block can be accepted into the buffer and the plotter acknowledges this fact as shown in Figure 8-4.

First, the SET OUTPUT MODE instruction is sent to specify a two hundred millisecond turn-around delay with default values for Output Trigger, Echo Bypass and Terminator, as follows:

Procedure

Send ESC . M 2 Ø Ø :	SET OUTPUT MODE instruction with parameters.

Second, the SET HANDSHAKE MODE 2 instruction, with an excessive data block size, is sent:

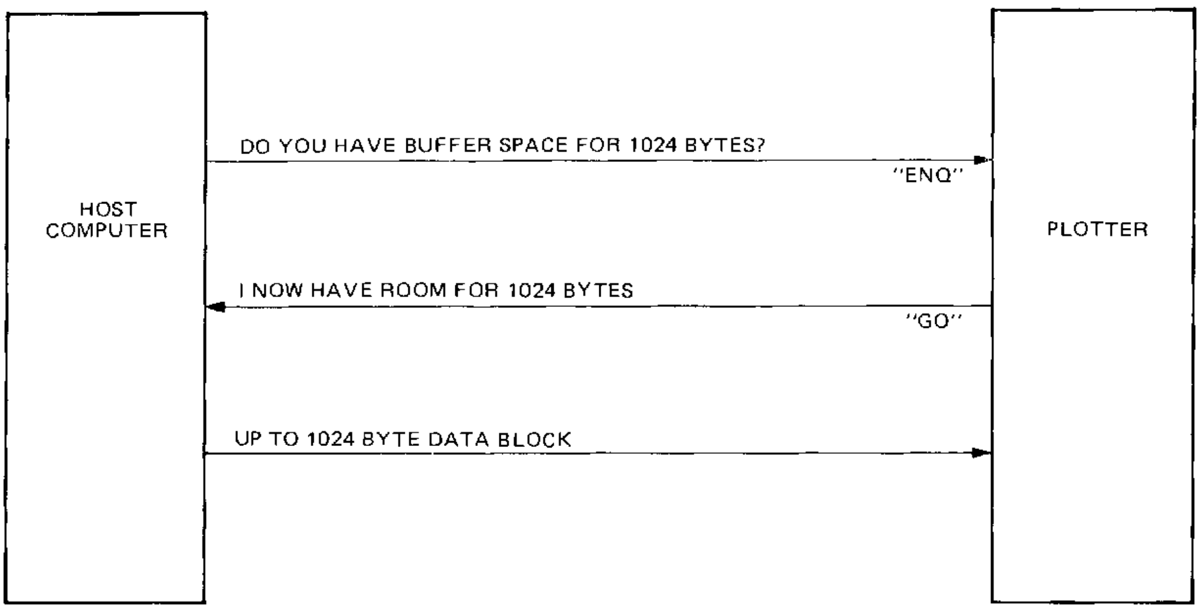

Figure 8-4. Handshake Mode 2

Procedure	Send	ESC . I	SET HANDSHAKE MODE 2 instruction.
		3 5 3 6	Excessive data block byte size.
		;	Delimiter.
		5	Handshake enable signal, this is the decimal value of ASCII character ENQ.
		;	Delimiter.
		7 1 ; 7 9	Handshake string, this is the decimal value of ASCII characters GO.
		:	Instruction terminator.

The plotter is now asked if it has buffer storage for a data block of the size specified in the Handshake Mode instruction.

Procedure	Send (CNTL) (E)	Keyboard equivalent of the ASCII character ENQ.

Result The plotter checks its buffer space and determines that it does not have enough space for this block size hence, it does not transmit the handshake data string (GO).

Next, a block size within the buffer capacity of the plotter is specified in the SET HANDSHAKE MODE 2 instruction.

Procedure	Send (ESC) (.) (J)	ABORT DEVICE CONTROL instruction (aborts previous handshake request).
	(ESC) (.) (I)	SET HANDSHAKE MODE 2 instruction.
	(1) (Ø) (2) (4)	Data block byte size.
	(;)	Delimiter.
	(5)	Handshake enable; ASCII character ENQ.
	(;)	Delimiter.
	(7) (1) (;) (7) (9)	Handshake string; ASCII characters GO.
	(:)	Terminator.

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Next, as shown in Figure 8-4, the plotter is asked to check its buffer space and transmit the handshake string when the buffer can accommodate a data block. Note that the plotter response is delayed two hundred milliseconds as specified in the Set Output Mode instruction.

Procedure	Send (CNTL) (E)	Keyboard equivalent of the ASCII character ENQ.

Result Plotter transmits GO indicating buffer has space for a data block of 1024 bytes. The handshake procedure has been completed and the Host Computer can now send a data block.

Set Extended Output and Handshake Mode

The SET EXTENDED OUTPUT AND HANDSHAKE MODE instruction establishes a procedure in conjunction with the Set Output Mode and Set Handshake Mode 1 or Mode 2 that can be followed to permit blocks of graphic instructions to be transferred from the host computer to the input buffer of the plotter. This instruction can also be used to inject a 0 to 10 second (approximate) delay prior to each character that is ouput from the plotter.

Refer to Chapter 10 for a detailed description of the SET EXTENDED OUTPUT AND HANDSHAKE MODE instruction.

An example SET EXTENDED OUTPUT AND HANDSHAKE MODE instruction is illustrated in Figure 8-5. As a demonstration of this instruction the plotter is asked to accept a specified size data block. After a specified turn-around delay and a specified output character delay, the plotter acknowledges as shown in Figure 8-5.

First, the Set Output Mode instruction is sent to specify a two hundred millisecond turn-around delay with default values for output trigger, echo bypass and terminator, as follows:

Procedure Send ESC . M 2 Ø Ø : Set OUTPUT MODE instruction with parameters.

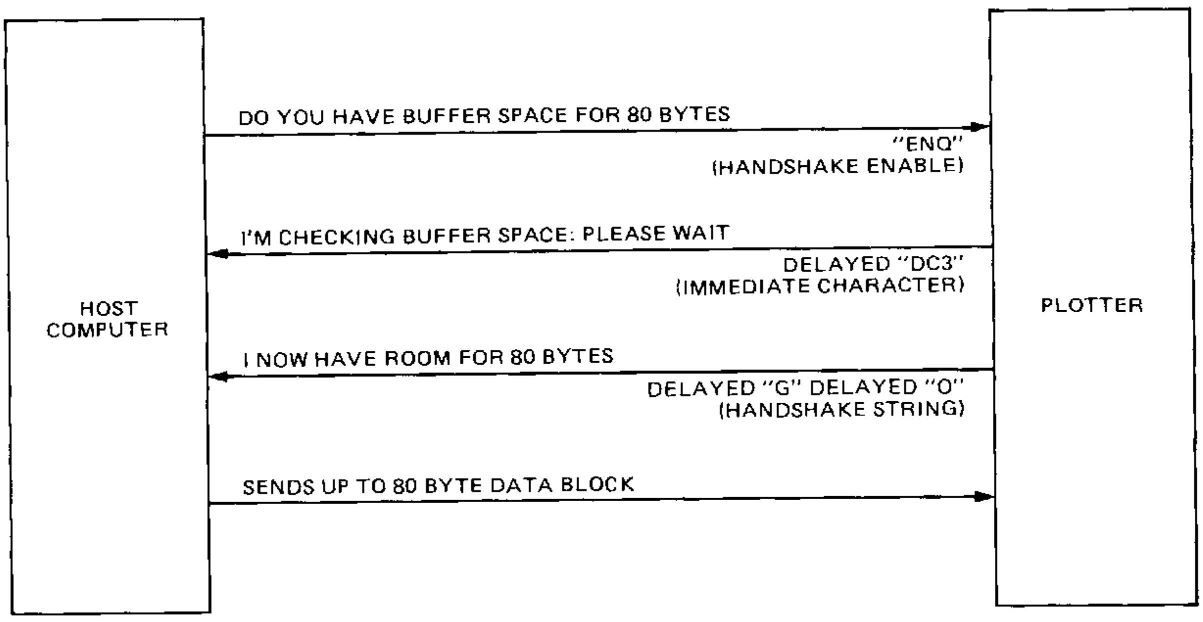

Figure 8-5. Set Extended Output and Handshake Mode

Second, the Set Handshake Mode 2 instruction is sent to specify data block size, handshake enable, and handshake string characters.

Procedure Send ESC . I	SET HANDSHAKE MODE 2 instruction.
8 Ø	Data block byte size.
;	Delimiter.
5	Handshake enable; ASCII character ENQ.
;	Delimiter.
7 1 ; 7 9	Handshake string; ASCII character GO.
:	Terminator.

Next, the SET EXTENDED OUTPUT AND HANDSHAKE MODE instruction is sent to specify a 50 milliseconds delay prior to each plotter output character and also the Immediate Response String.

Procedure Send ESC . N	SET EXTENDED OUTPUT AND HANDSHAKE MODE instruction.
5 Ø	Plotter output character delay.
;	Delimiter.
1 9	Immediate response string; ASCII character DC3.
:	Terminator.

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Then, as shown in Figure 8-5, the plotter is asked to check its buffer space and transmit the immediate response string, followed by the handshake string when the buffer can accommodate a data block. Note that the immediate response character output is delayed a total of 250 milliseconds, 200 milliseconds as specified in the Set Output Mode instruction and 50 milliseconds as specified by the SET EXTENDED OUTPUT AND HANDSHAKE MODE instruction. Also note that each subsequent output character is delayed 50 milliseconds as specified by the SET EXTENDED OUTPUT AND HANDSHAKE MODE instruction.

Procedure Send CNTL E — Keyboard equivalent of the ASCII character ENQ.

Result Plotter transmits DC3 indicating "wait" followed by GO indicating buffer has space for a data block of 80 bytes. The handshake procedure has been completed and the host computer can now send a data block.

NOTE

The delay injected prior to the output of each character can be used to compensate for those computers that can receive data bits at the selected baud rate, but cannot process a continuous stream of characters at that baud rate, due to limited buffering in the I/O port.

Set Plotter Configuration

General

The SET PLOTTER CONFIGURATION instruction is used to establish five different configuration options. These configuration options are determined by two parameters. The first parameter specifies a maximum available buffer size. The second parameter specifies four binary bits as desired to establish Hardwired Handshake, Enable Data Transmission, Data Indicator and Monitor Mode options.

The initialized state of the second parameter is set only at plotter power-on, and the state of bit 0 and bit 1 is determined by the position of the MODEM/HARDWIRE switch. If the MODEM switch position is selected, all four bits will be initialized to "0". If the HARDWIRE switch position is selected, bits 0 and 1 will be set to "1" and bits 2 and 3 will be set to "0". Subsequent states for these four bits can only be changed programmatically. Refer to Chapter 10 for a detailed description of the SET PLOTTER CONFIGURATION instruction.

Set Buffer Size

This parameter is used to set the apparent maximum buffer size of the plotter. For example, this parameter can be used in conjunction with the Monitor Mode option to help ensure that graphic data does not overflow buffer space when plotters are connected in series. The actual buffer size and available space are unchanged, but the plotters' response to an output request for buffer size or buffer space is restricted to a value equal to or less than the value specified by this parameter. This parameter does not effect "block size" as established by the Set Handshake Mode 1 or Set Handshake Mode 2 instructions.

Hardwired Handshake (Bit 0)

In a hardwired environment, where the RS-232-C Data Terminal Ready (CD) control line is not normally used for protocol purposes, bit 0 of the SET PLOTTER CONFIGURATION instruction can be used in lieu of the ESC . H, ESC . I, and ESC . N instructions to establish a "Buffer Available Flag". Handshaking is accomplished when the host computer monitors the "high" or "low" state of control line (CD). While this configuration option is active, the plotter sets control line (CD) "high" when the existing buffer space is > = the current data block size.

The default block size for this configuration option is 80 bytes, as established by the ESC . H or ESC . I instructions (refer to Chapter 10 for details). The Hardwired Handshake option is normally used in conjunction with the Enable Data Transmission option described in the following paragraph.

Enable Data Transmission (Bit 1)

This configuration option will normally be used in a hardwired environment (no modems) to enable data transmission on the Transmitted Data (BA) and Received Data (BB) lines independently of conditions normally required by control line protocol. This configuration allows the plotter to be operated in a 3-wire hook-up in which the only lines present are Transmitted Data (BA), Received Data (BB), and ground. Refer to Figure 11-4 for the flow diagram of plotter modes control line protocol.

Data Indicator (Bit 2)

When this configuration option is active (bit 2 set to 1) the STBY lamp will flash if data has been sent to the plotter within the last one quarter second. This indication makes it easier to tell if data is being sent to the plotter and is available only when the plotter is programmed "on" in the On Line or Local modes.

Monitor Mode (Bit 3)

The Monitor Mode is available only when the plotter is programmed "on" in the On Line mode, and when active, allows all data that is received or transmitted by the plotter to be displayed on the terminal. This configuration option is primarily intended to be used as a "debugging" aid for program development. Since operating environments vary, data are transmitted to the terminal in different ways as follows: (1) all data which are sent to the MODEM connector from the computer are also seen at the TERMINAL connector; (2) all plotter output responses are sent to both the computer and terminal if the DUPLEX switches on the plotter and terminal are set to HALF; and (3) when the computer is working in an echo-plex environment and the DUPLEX switches on the plotter and terminal are set to FULL, all plotter output responses are echoed from the computer, through the plotter, to the terminal. "Echo-plex environment" is one in which data received by the computers' communication line I/O port is "echoed" back to the sending device. All data that the terminal sends to the plotter, except "break" are ignored while the Monitor Mode is active.

With the DUPLEX switches set to FULL, and Monitor Mode active, it is possible to connect several plotters in series so that all of them execute the same graphics data. In this configuration, the output responses of the first plotter in line are the ones which are returned to the computer. All the other plotters receive the output requests, but their responses are ignored in each case by the next higher plotter in line. Therefore, the output responses of the first plotter must be true for all the other plotters. For example, to help ensure that graphics data does not overflow the plotters' buffers in the series-connected configuration, the first parameter of the SET PLOTTER CONFIGURATION instruction can be used to set the apparent maximum buffer size of the plotters to a smaller value.

To demonstrate the SET PLOTTER CONFIGURATION instruction, the plotter is set-up to plot a circular "clover leaf" pattern and to "output buffer size" (1128 bytes) indicating that all data has been plotted. This illustration assumes that the plotter is connected to a computer and a terminal. In addition, the DUPLEX switches must be set and the program must be sent from the computer.

Procedure Initialize plotter and move pen arm to center of platen.

Send ESC . (	PLOTTER ON instruction.
ESC . @	SET PLOTTER CONFIGURATION instruction.
;	Delimiter.
1 5	This is the decimal value equivalent of binary number 1111 which sets all bit options of the second parameter to "1".
:	Terminator.
w	ROTATE instruction.
t	ARC CLOCKWISE instruction.
d @	Radius parameter, 256 plotter units (MBN format).
w d	ROTATE 90° (MBA format).
t	ARC CLOCKWISE using last radius parameter.
w d	ROTATE 90°.

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t	ARC CLOCKWISE using last radius parameter.
w d	ROTATE 90°.
t	ARC CLOCKWISE using last radius parameter.
w d	ROTATE 90°.
t	ARC CLOCKWISE using last radius parameter.
}	Terminator.
ESC . L	OUTPUT BUFFER SIZE instruction.

Result During the time the "clover leaf" pattern is being plotted, observe that the STBY lamp is flashing and that all input and output data are displayed on the terminal.

Output Extended Status

NOTE

This instruction pertains to the 7221S plotter and if sent to the 7221B plotter the response will indicate the paper advance option is "off" and roll paper is not loaded, i.e., the response is "2" (binary 10).

Upon receipt of the OUTPUT EXTENDED STATUS instruction the plotter transmits encoded information as a decimal number to define the status of the paper advance option at the time this instruction is received. Refer to Chapter 10 for a detailed description of the instruction. The following is the response after roll paper is loaded and the paper is advanced a full page.

Procedure Send (~) (+) — ADVANCE FULL PAGE instruction.

(ESC) (.) (O) — OUTPUT EXTENDED STATUS instruction.

Result The plotter transmits a 2-bit status word as a one-character decimal number indicating the following:

DECIMAL NUMBER	BINARY EQUIVALENT	DECODED STATUS
1	0 1	
	1	Paper advance option is "on".
	0	Roll paper is sensed after paper is advanced one full page.

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The following is the response if roll paper is loaded, an advance is completed, and the pen has then been lowered to the paper either programmatically or by front panel control.

Procedure	Send (~) (+)	ADVANCE FULL PAGE instruction.
	(p) (g) (4) (O) (()	MOVE instruction to X,Y = 1000, 1000 plotter units.
	(q)	DRAW instruction lowers pen.
	(ESC) (.) (O)	OUTPUT EXTENDED STATUS instruction.

Result Roll paper is advanced one full page, the pen moves to the specified coordinates and lowers, putting a mark on the paper. The transmitted status word is as follows:

DECIMAL NUMBER	BINARY EQUIVALENT	DECODED STATUS
3	1 1	
	1 (right bit)	Paper advance option is "on".
	1 (left bit)	Paper is "dirty".

The following is the response if an out-of-paper condition is sensed before or at the completion of an advance operation.

Procedure Remove roll paper from plotter.

Send (~) (-)	ADVANCE HALF PAGE instruction.
(ESC) (.) (O)	OUTPUT EXTENDED STATUS instruction.

Result The transmitted status word is as follows:

DECIMAL NUMBER	BINARY EQUIVALENT	DECODED STATUS
2	1 0	
	0 (right bit)	Paper advance option is "off". (There is no roll paper loaded.)
	1 (left bit)	Advance operation resulted in sensing an out-of-paper condition.

Chapter 9
Parameter Encoding

Introduction

This chapter describes how the various types of numeric plotter parameters are formatted and encoded into binary character codes. The binary format philosophy is explained, and the parameter formats and bit-assignments are diagrammed. Flow charts and examples of the encoding processes are included for each type of numeric parameter. The following discussions are presented in this chapter.

- **Parameter Types**
- **Parameter Length**
- **The Binary Format Philosophy**
- **The Single-Byte Number (SBN)**
- **The Multiple-Byte Number (MBN)**
- **The Multiple-Byte Pair of Numbers (MBP)**
- **The Pair of Multiple-Byte Numbers (PMB)**
- **The Multiple-Byte Angle (MBA)**

Parameter Types

There are five types of numeric parameters:

Single-Byte Number (SBN format)
Multiple-Byte Number (MBN format)
Multiple-Byte Pair of Numbers (MBP format)
Pair of Multiple-Byte Numbers (PMB format)
Multiple-Byte Angle (MBA format)

NOTE

Appendix B, "Binary Coding Table", presents the structures, value ranges and lengths associated with each of the five types.

The basic format of each type is designed to efficiently represent a specific class of numeric data. The type of parameter used to express a numeric value is a specified property of the graphic instruction which it accompanies. Therefore a parameter must be encoded in the basic format required by the associated graphic instruction (refer to Chapter 10 for these specified relationships).

Parameter Length

The Single-Byte Number (SBN) is always one byte in length. The other four types can be of variable length, up to a specified number of bytes. The minimum number of bytes required to express a particular value depends on the magnitude or resolution of the values, and the class of data to which the value belongs. The user may maximize coding efficiency by constructing the parameter with only the minimum number of bytes required to faithfully represent the current data value or values.

The Binary Format Philosophy

The binary format implemented for the HP Model 7221B and 7221S Plotter permits minimal I/O traffic volume and optimal use of available data buffer capacity. The encoding scheme includes a system of identifying the general function and meaning of each byte of information transmitted to the plotter. Classification is keyed on the values of bits 5 and 6 (i.e., 2^5 and 2^6), and in some cases bit 4 (2^4), of each byte of encoded information, as follows:

CLASS OF INFORMATION	DECIMAL BYTE VALUE	BIT 6	BIT 5	BIT 4
Control Codes	00 – 31	0	0	
Graphic Instruction Codes	112 – 126	1	1	1
MBA, MBN, MBP Parameters (First Byte)	96 – 111	1	1	0
MBA, MBN, MBP Parameters (Succeeding Bytes)	32 – 95	{0 1	1 0	
PMB Parameters (X Component)	64 – 95	1	0	
PMB Parameters (Y Component)	32 – 63	0	1	
SBN Parameters	32 – 95	{0 1	1 0	

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Control Bits

In order that parameter bytes conform to the foregoing binary format, certain of their bits are reserved as **control bits.** In some cases the control bits have fixed binary values. The parameter format diagram in this chapter refer to these bits as "flag" bits and show their binary values in the following manner:

$$P = \underbrace{\boxed{1\ \ 1\ \ 0}}_{\text{flag bits}}\boxed{n_3\ \ n_2\ \ n_1\ \ n_0} \qquad \textbf{or} \qquad P = \underbrace{\boxed{1\ \ 0}}_{\text{flag bits}}\boxed{X_4\ \ X_3\ \ X_2\ \ X_1\ \ X_0}$$

In other cases, the byte value must be in the range of 32 – 95, but bit 5 (2^5) has numeric significance to the data value expressed by the parameter. In that event the control bit is bit 6 (2^6) and must be encoded as the binary complement of the value of bit 5. The parameter format diagrams refer to this bit as the "complement" bit and represents its value with the letter "c", as follows:

$$P = \boxed{c}\boxed{n_5\ \ n_4\ \ n_3\ \ n_2\ \ n_1\ \ n_0}$$

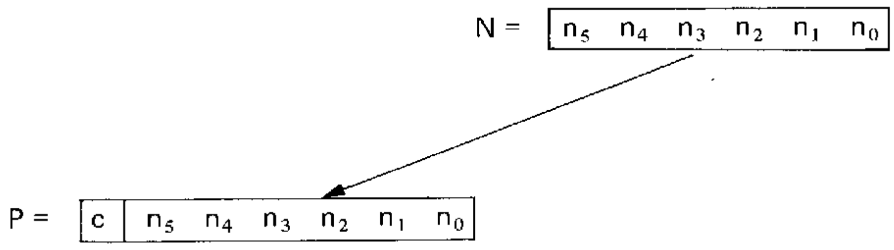
complement bit

The Single-Byte Number (SBN)

This parameter expresses positive integers in the range of 0 to 63, and is always one byte in length. Example: Pen Velocity, in cm/sec.

Formats and Bit-Assignment

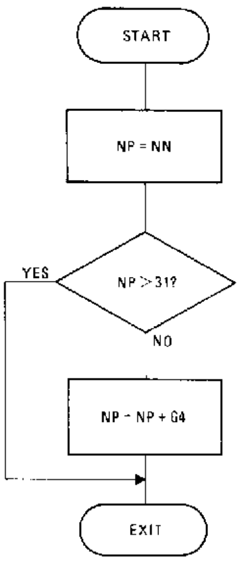
Range of N: 0 to 63



Encoding Process

In the following process, the data value N is encoded to a parameter byte in SBN format. "NP" refers to the decimal equivalent value of the encoded parameter byte, and NN the decimal value of N.

PROCESS FLOW



EXPLANATION	EXAMPLE
	(Assume NN = 30)
	N = 0 0 1 1 1 1 0
Assemble bits n_0 - n_5 into the SBN byte at bit positions 0-5.	NP = 30 P = 0 0 1 1 1 1 0
Is n_5 = 1 (NP = 32 or greater)?	
If n_5 = 0 (NP < 32), set the complement control bit, c = 1, in the parameter byte (by adding 64 to the decimal value of the byte).	NP = 30 + 64 = 94 P = 1 0 1 1 1 1 0

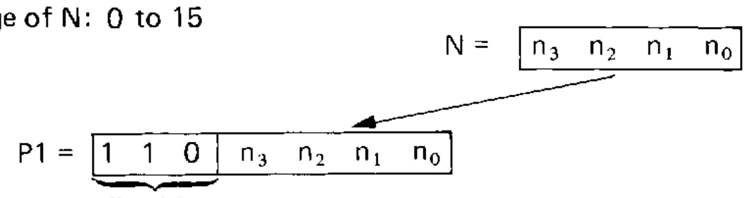
The Multiple-Byte Number (MBN)

This parameter expresses positive integers in the range of 0 to 32767. It may be from one to three bytes in length, depending on the magnitude of the current data value. Example: Length of an arc radius, in plotter units.

Formats and Bit-Assignments

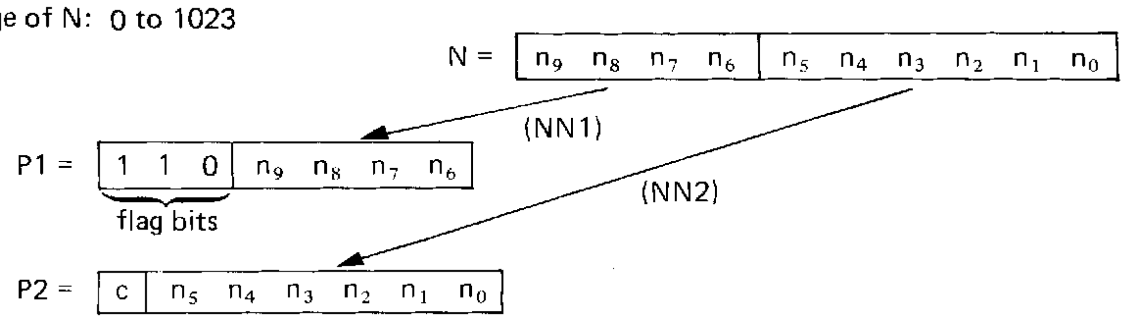
One-Byte Format

Range of N: 0 to 15



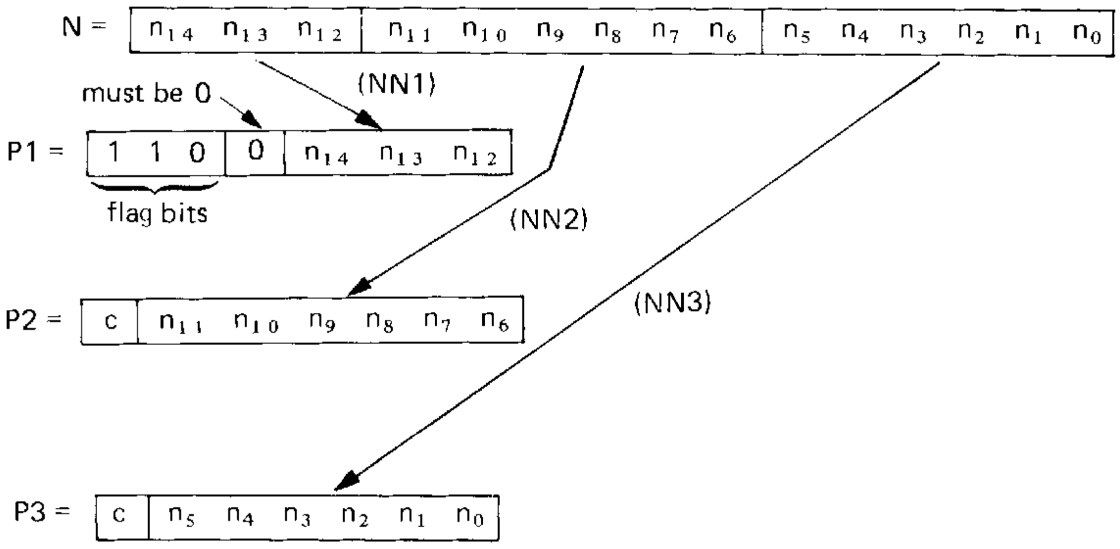
Two-Byte Format

Range of N: 0 to 1023



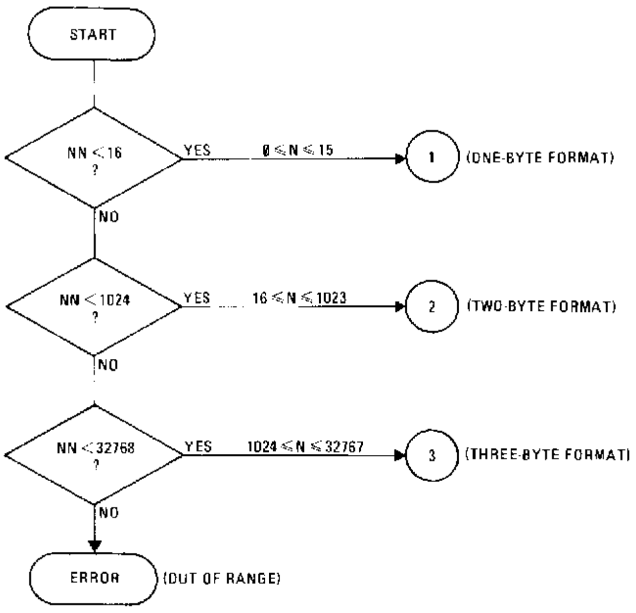
Three-Byte Format

Range of N: 0 to 32767



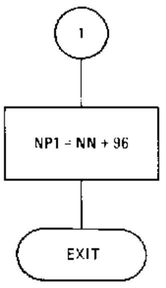
Parameter Length

The optimum length of an MBN parameter can be determined by a simple process which evaluates the range of the current value of N and branches to the appropriate encoding process (NN = decimal value of N).

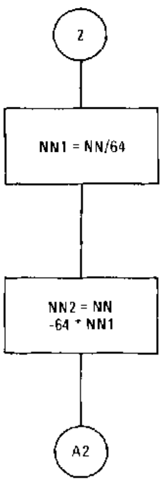


MBN Encoding Processes

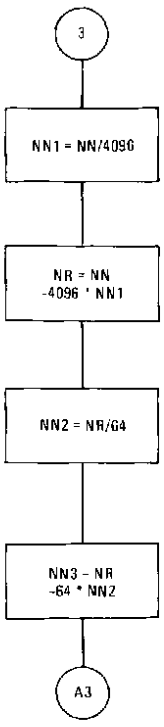
One-Byte Format

PROCESS FLOW	EXPLANATION	EXAMPLE
	Assemble bits n_0 - n_3 into the one byte of the MBN parameter, at bit positions 0 - 3. Set "flag" bits (at positions 4 - 6) = "110", by adding 96 to value of byte P1.	Assume NN = 13 NP1 = 13 + 96 = 109 P1 = 1 1 0 1 1 0 1

Two-Byte Format

PROCESS FLOW	EXPLANATION	EXAMPLE
		None Given
	Calculate NN1, the decimal integer value of bits n_6 - n_9. This value will be assembled into byte P1.	
	Calculate NN2, the decimal integer value of the remainder of the bits of N (bits n_0 - n_5). This value will be assembled into byte P2.	
	Proceed to assembly subroutine.	

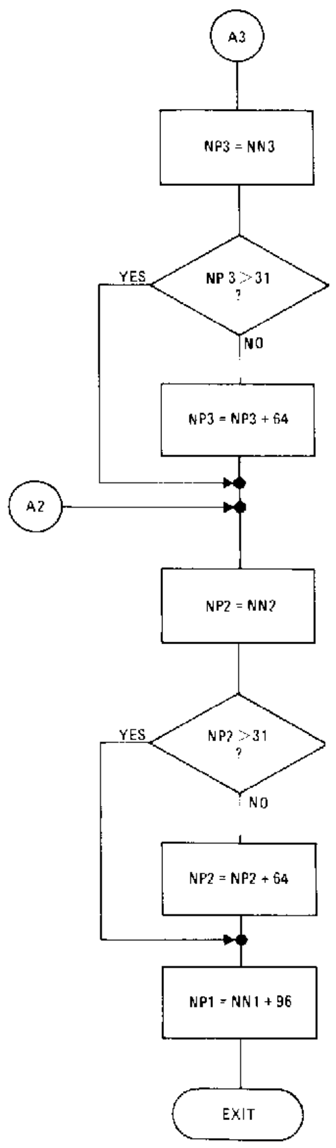
Three-Byte Format

PROCESS FLOW	EXPLANATION	EXAMPLE
		Assume NN = 7041
	Calculate NN1, the decimal integer value of bits n_{12} - n_{14}, to be assembled into parameter byte P1.	NN1 = 7041/4096 = 1
	Calculate NR, the decimal value of the remainder of the bits (n_0 - n_{11}) of N.	NR = 7041 - 4096 = 2945
	Calculate NN2, the decimal integer value of bits n_6 - n_{11}, to be assembled into parameter byte P2.	NN2 = 2945/64 = 46
	Calculate NN3, the decimal value of bits n_0 - n_5, to be assembled into parameter byte P3.	NN3 = 2945 - 64 * 46 = 2945 - 2944 = 1
	Proceed to assembly subroutine.	

Assembly (Two-and Three-Byte)

The previously-calculated portions of the data bits of N are assembled into the MBN parameter bytes, and the control bits are set.

PROCESS FLOW



EXPLANATION	EXAMPLE
(From three-byte calculations)	(NN = 7041, cont'd)
Assemble the value of bits n_0 - n_5 into P3, the third MBN byte, at bits 0 - 5.	NP3 = 1 P3 = 0 0 0 0 0 0 1
If bit 5 of the byte = 0, set the complement control bit by adding 64 to the value of the parameter byte.	NP3 = 1 + 64 = 65 P3 = 1 0 0 0 0 0 1
(Entry from two-byte calculations)	
Assemble the pre-calculated value NN2 into parameter byte P2, at bits 0 - 5.	NP2 = 46 P2 = 0 1 0 1 1 1 0
Set complement control bit conditionally, as for P3.	NP2 = 46 (no change)
Assemble the pre-calculated value NN1 into parameter byte P1 at bits 0 - 3. Set the flag control bits = "110" by adding 96 to the value of the byte.	NP1 = 1 + 96 = 97 P1 = 1 1 0 0 0 0 1 Assembled Parameter P1 = 1 1 0 0 0 0 1 P2 = 0 1 0 1 1 1 0 P3 = 1 0 0 0 0 0 1

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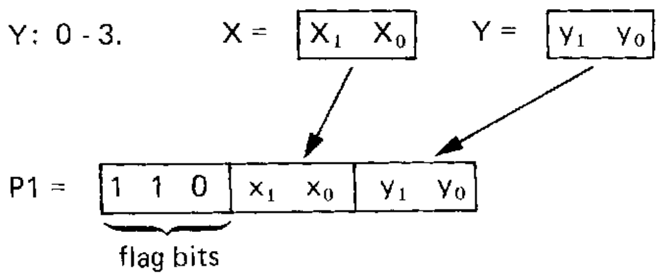
The Multiple-Byte Pair of Numbers (MBP)

This parameter expresses a pair of positive integers, each in the range 0 to 16383. It may be from one to five bytes in length, depending on the magnitude of the larger of the two current data values. Example: Absolute X, Y co-ordinates, in plotter units.

Formats and Bit-Assignments

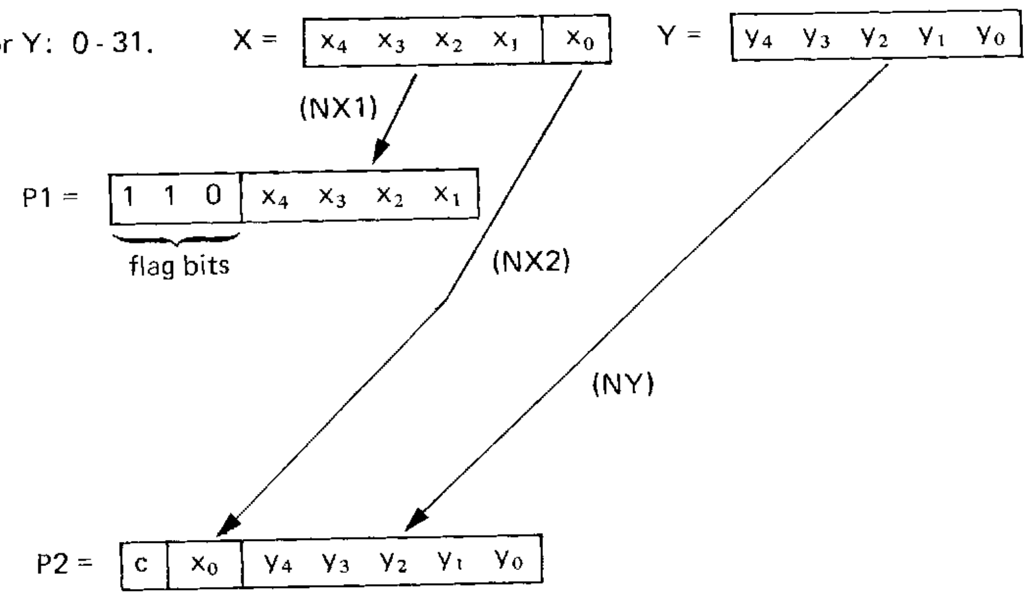
One-Byte Format

Range of X or Y: 0 - 3.



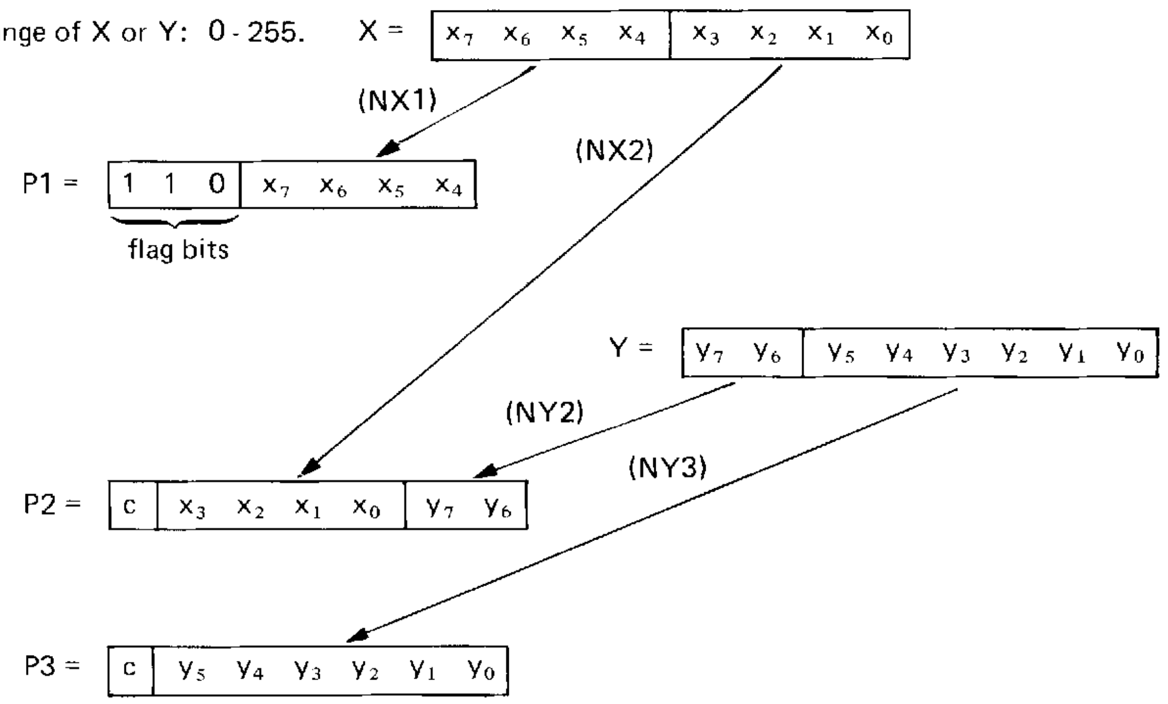
Two-Byte Format

Range of X or Y: 0 - 31.



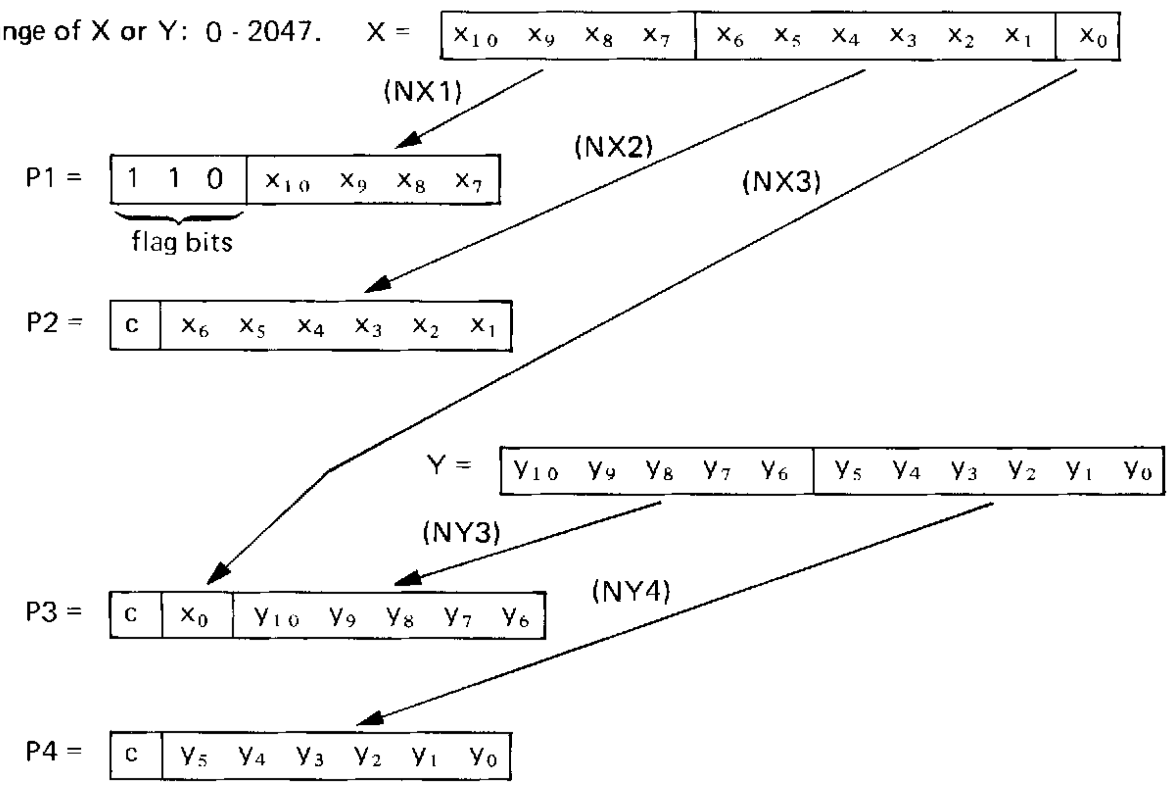
Three-Byte Format

Range of X or Y: 0 - 255.



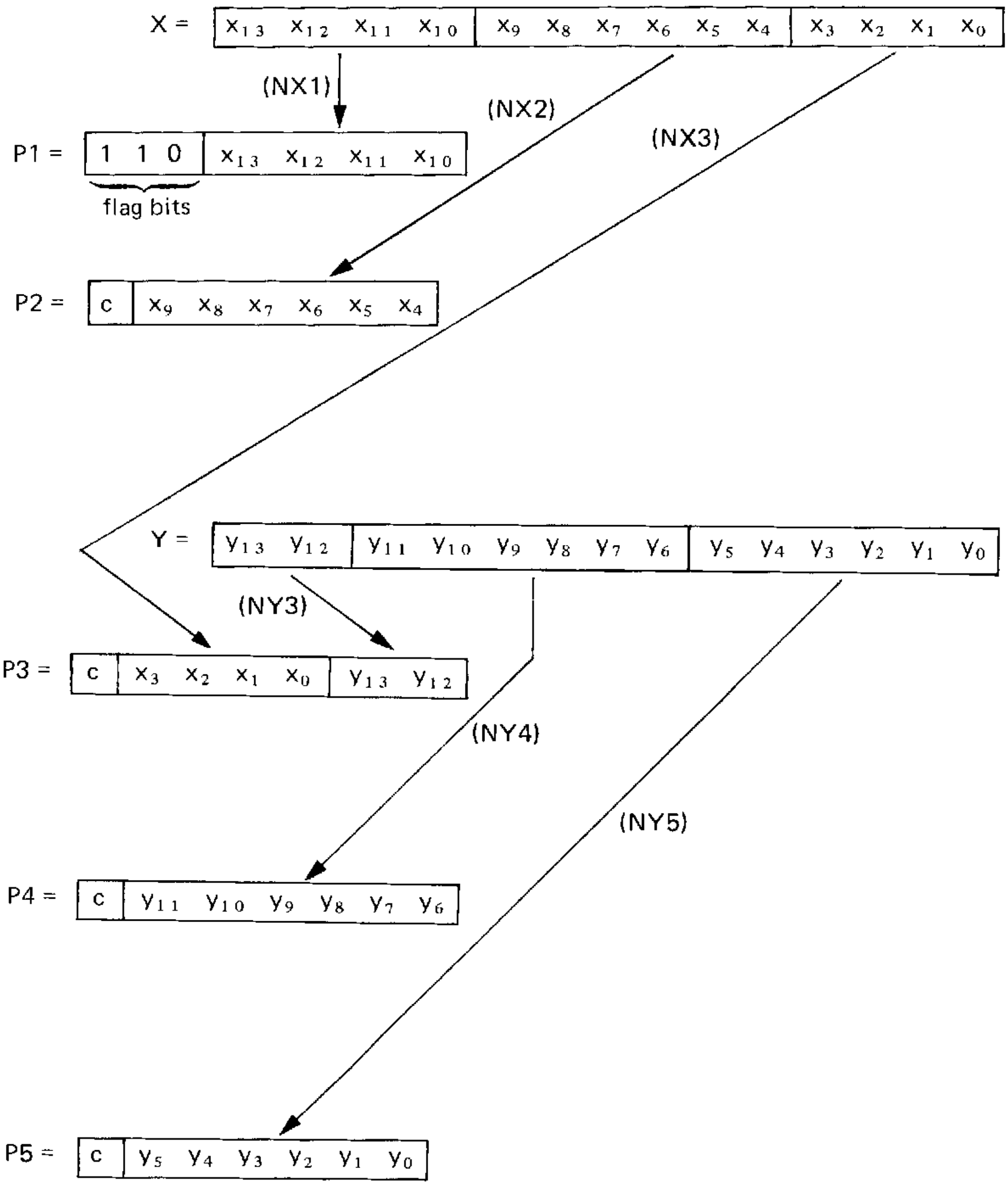
Four-Byte Format

Range of X or Y: 0 - 2047.



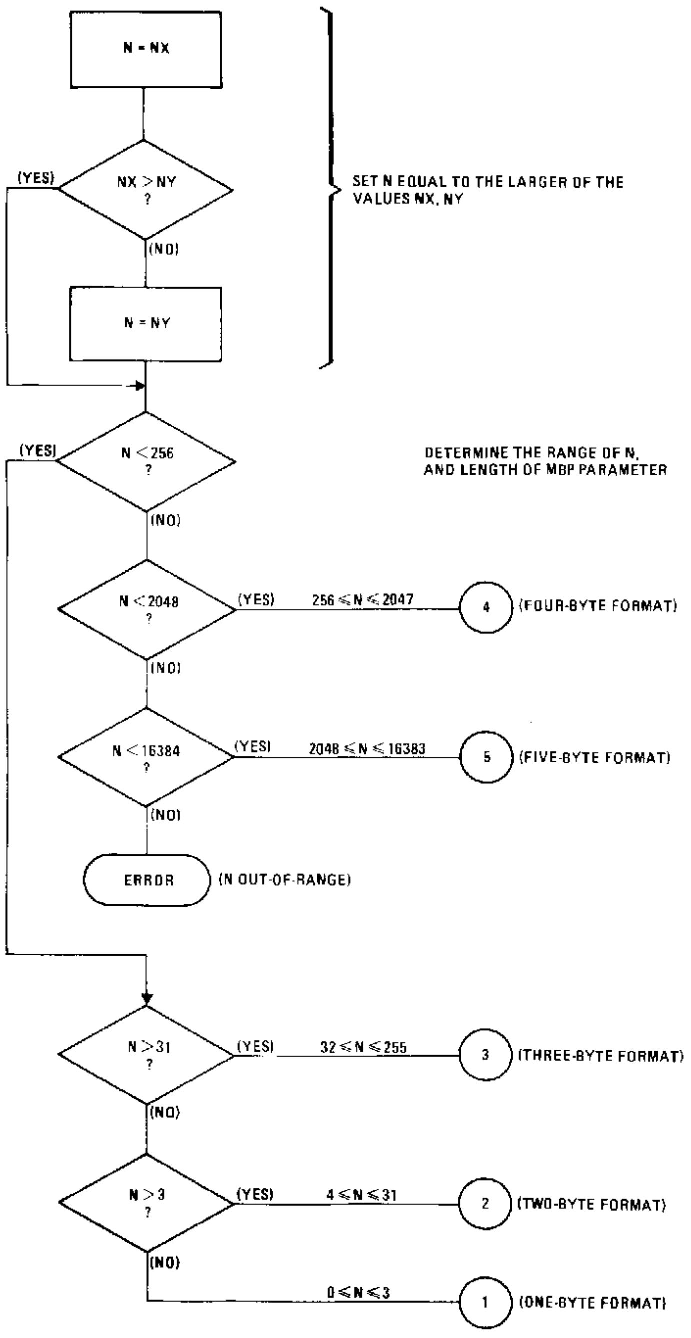
Five-Byte Format

Range of X or Y: 0 - 16383.



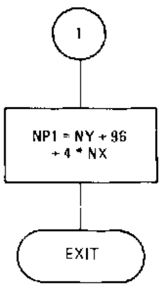
MBP Parameter Length

The optimum length of an MBP parameter can be determined by evaluating the range of the larger of the current pair of data values NX, NY. The following evaluation process assumes that, with default graph limits and grid size, NX and NY most often represent plotting co-ordinates in the range of 256 to 2047 plotter units. The flow branches to the appropriate encoding subroutines.

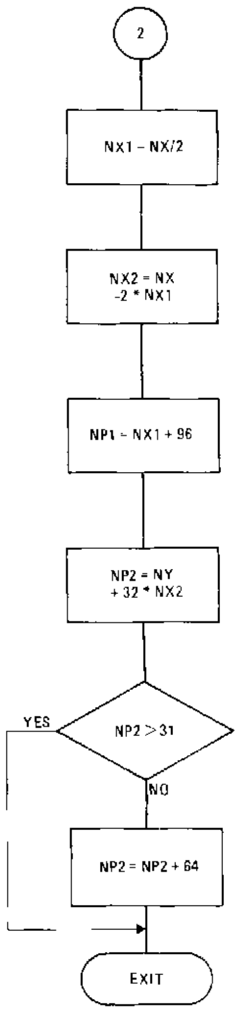


MBP Encoding Processes

One-Byte Format

FLOW PROCESS	EXPLANATION	EXAMPLE
	(From length-evaluation) Assemble the bits of X and Y into the parameter byte: Y_0 - Y_1 into bits 0 - 1, X_0 - X_1 into bits 2 - 3. Set the flag bits = "110" by adding 96.	(Assume NX, NY = 3, 1) (X = $\boxed{11}$ Y = $\boxed{01}$) NP1 = 1 + 96 + 4 * 3 = 109 P1 = $\boxed{1\ 1\ 0\ 1\ 1\ 0\ 1}$

Two-Byte Format

FLOW PROCESS	EXPLANATION	EXAMPLE
	(From length-evaluation)	(Assume NX, NY = 27,3)
	Calculate NX1, the decimal integer value of bits X_1 - X_4, to be assembled into parameter byte P1.	NX1 = 27/2 = 13
	Calculate the decimal value of X_0, to be assembled into byte P2.	NX2 = 27 - 2 * 13 = 1
	Assemble the value of X_1 - X_4 into byte P1 at bits 0 - 3. Set the flag bits = "110" by adding 96.	NP1 = 13 + 96 = 109 P1 = $\boxed{1\ 1\ 0\ 1\ 1\ 0\ 1}$
	Assemble the value of X_0 into P2 at bit 5, and the value of Y_0 - Y_4 into P2 at bits 0 - 4.	NP2 = 3 + 32 = 35 P2 = $\boxed{0\ 1\ 0\ 0\ 0\ 1\ 1}$
	If bit 5 of P2 = 0, set the complement control bit c = 1 by adding 64 to the value of P2.	NP2 = 35 (no change) Assembled Parameter P1 = $\boxed{1\ 1\ 0\ 1\ 1\ 0\ 1}$ P2 = $\boxed{0\ 1\ 0\ 0\ 0\ 1\ 1}$

Three-Byte Format

FLOW PROCESS	EXPLANATION	EXAMPLE
3	(From length evaluation)	(Assume NX, NY = 115, 225)
NX1 - NX/16	Calculate decimal-integer value of bits X_4 - X_7, to be assembled into parameter byte P1 at bits 0 - 3.	NX1 = 115/16 = 7
NX2 - NX -16 * NX1	Calculate decimal value of the remainder of the bits of X (X_0 - X_3), to be assembled into byte P2.	NX2 = 115 - 112 = 3
NY2 = NY/64	Calculate decimal integer value of bits Y_6 - Y_7, to be assembled into parameter byte P2.	NY2 = 225/64 = 3
NY3 - NY -64 * NY2	Calculate decimal value of the remainder of the bits of Y (Y_0 - Y_5) to be assembled into byte P3.	NY3 = 225 - 192 = 33
NP1 = NX1 + 96	Assemble pre-calculated value of bits X_4 - X_7 into P1 at bits 0 - 3. Set flag bits = "110" by adding 96.	NP1 = 7 + 96 = 103 P1 = 1 1 0 0 1 1 1
NP2 - NY2 +4 * NX2	Assemble pre-calculated values of X_0 - X_3 into P2 at bits 2 - 5, and Y_6 - Y_7 into P2 at bits 0 - 1.	NP2 = 3 + 12 = 15 P2 = 0 0 0 1 1 1 1
NP3 = NY3	Assemble pre-calculated value of Y_0 - Y_5 into P3 at bits 0 - 5.	NP3 = 33 P3 = 0 1 0 0 0 0 1
NP2 = NP2 [+64] NP3 = NP3 [+64]	Conditionally, set complement control bits of P2 and P3, by adding 64.	NP2 = 15 + 64 = 79 NP3 = 33 (no change) Assembled Parameter P1 = 1 1 0 0 1 1 1 P2 = 1 0 0 1 1 1 1 P3 = 0 1 0 0 0 0 1
EXIT		

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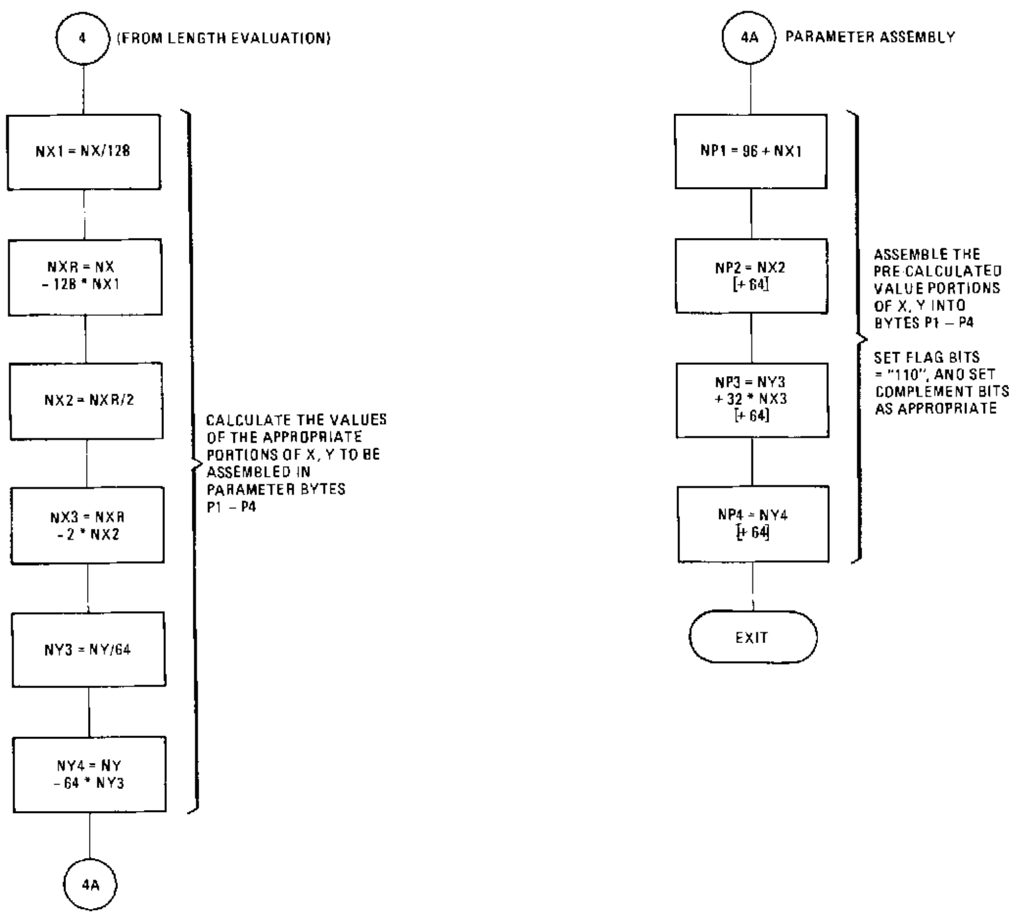
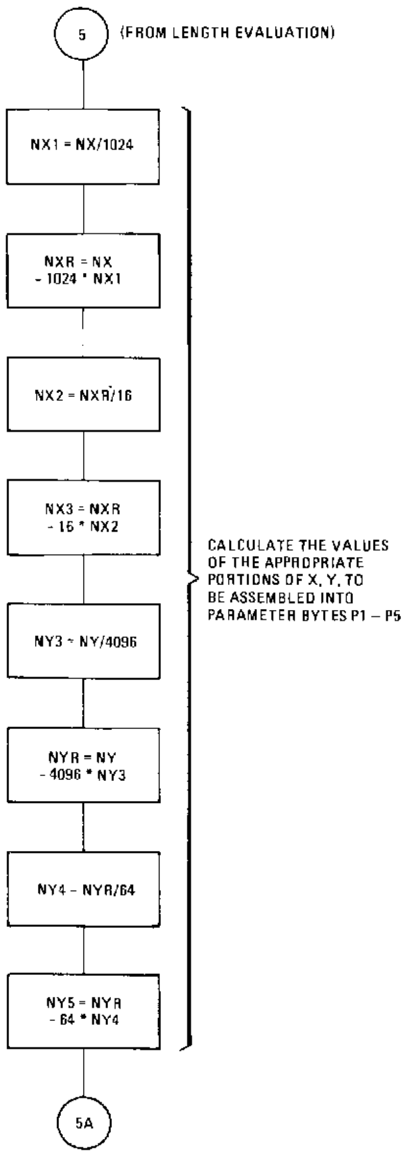
NOTE

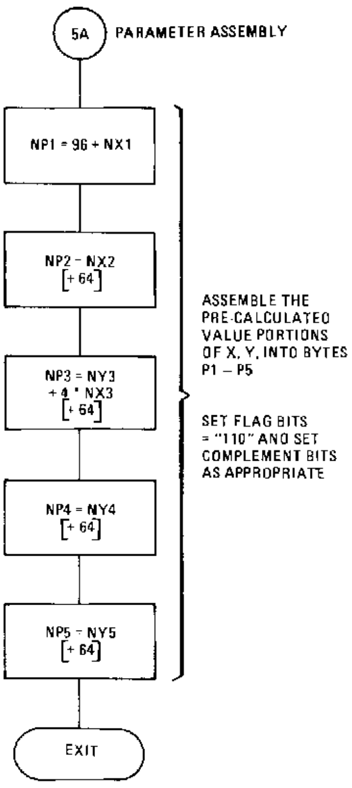
The Four-Byte and Five-Byte formats are encoded along the same algorithmic lines as the two- and three-byte formats. The flow diagrams are included below, but the detailed explanations and examples are omitted, to avoid redundancy.

Four-Byte Format



Five-Byte Format





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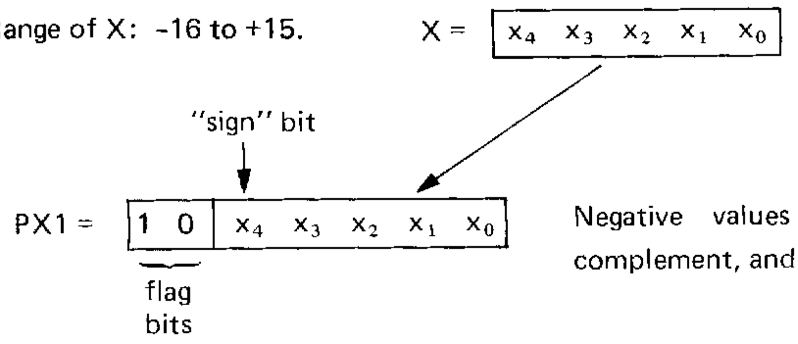
The Pair of Multiple-Byte Numbers (PMB)

This parameter expresses a pair of integers, each of which may range from -16384 to +16383. There are two separate components of the parameter. Each component may be from one to three bytes in length, depending on the magnitude of the corresponding current data value. Example: Incremental X, Y co-ordinates, in plotter units.

Formats and Bit-Assignments

One-Byte Format (X-Component)

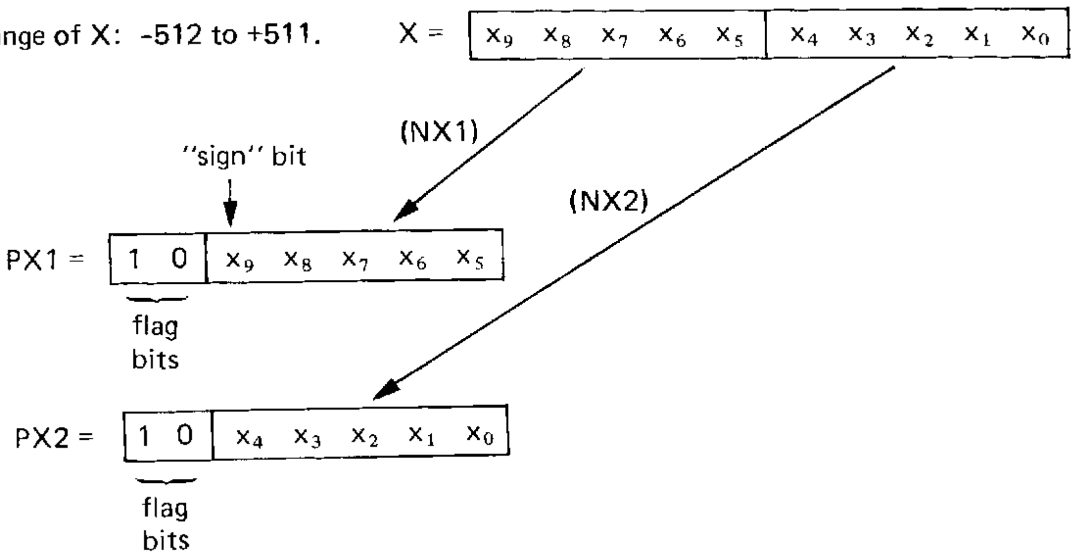
Range of X: -16 to +15.



Negative values are expressed as two's complement, and "sign" bit = 1.

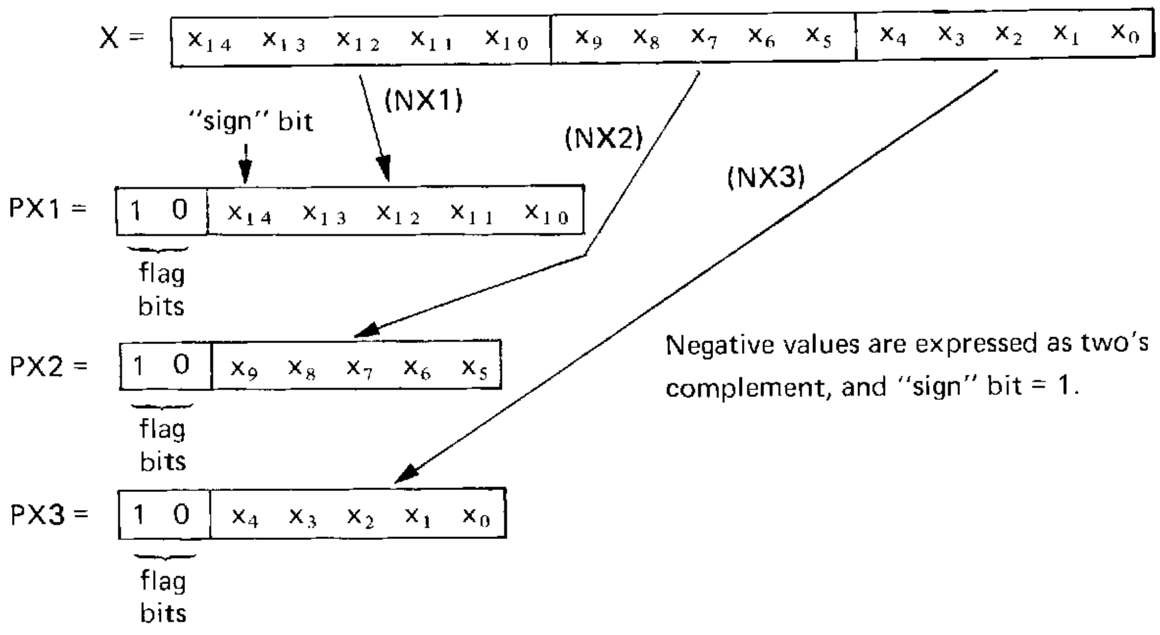
Two-Byte Format (X-Component)

Range of X: -512 to +511.

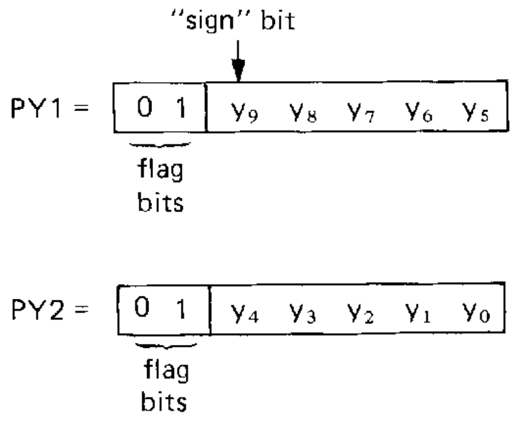


Three-Byte Format (X-Component)

Range of X: -16384 to +16383.



The **Y-component** PMB parameters have the same formats, except that the flag bits = "01"; for example, the two-byte format is:



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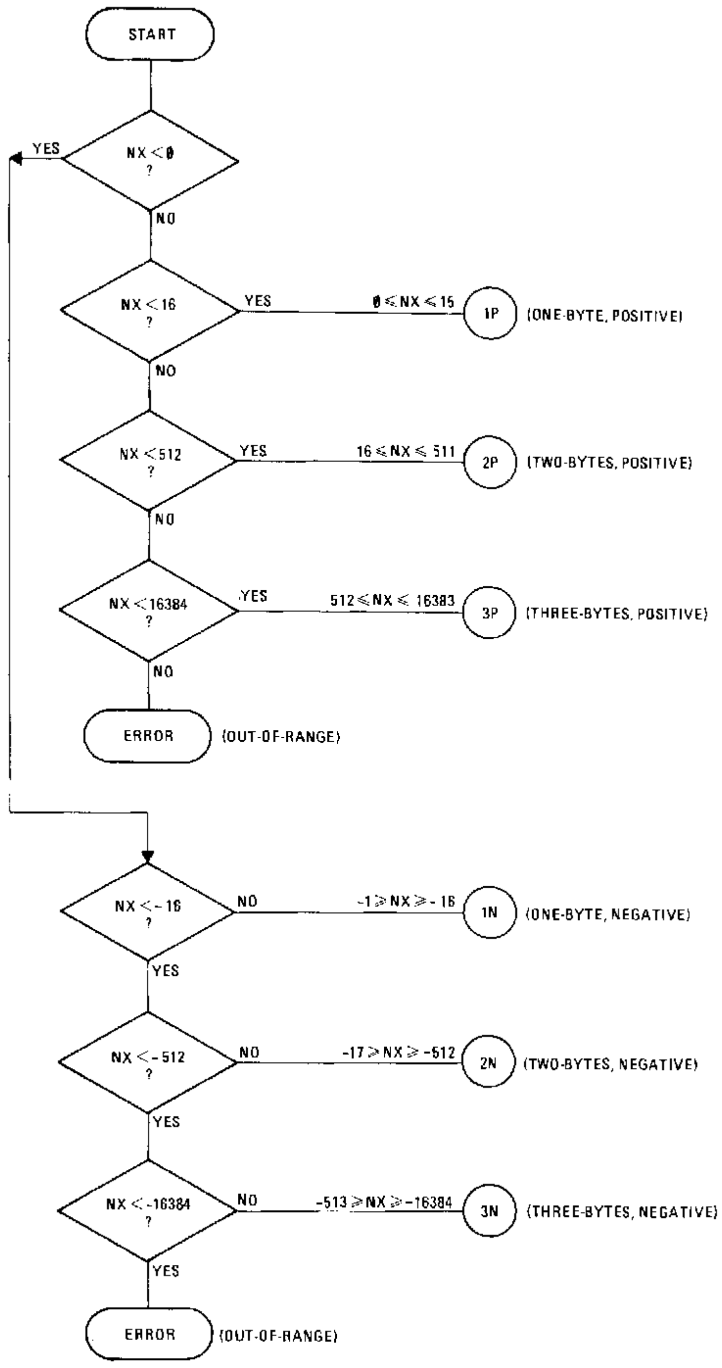
PMB Parameter Length

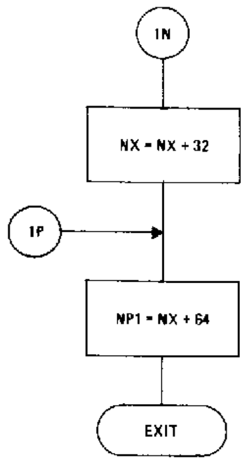
Although a PMB parameter must contain both an X-component and a Y-component, the lengths of each may be computed and encoded separately. For example, the X-component may be three bytes in length, and the Y-component only one byte in length. The optimum lengths of both are computed by identical methods. The following flow process determines the optimum length of a PMB-X parameter and branches to the appropriate encoding subroutine.


START
YES
NX < 0 ?
NO
NX < 16 ?
YES
0 ≤ NX ≤ 15
1P
(ONE-BYTE, POSITIVE)
NO
NX < 512 ?
YES
16 ≤ NX ≤ 511
2P
(TWO-BYTES, POSITIVE)
NO
NX < 16384 ?
YES
512 ≤ NX ≤ 16383
3P
(THREE-BYTES, POSITIVE)
NO
ERROR
(OUT-OF-RANGE)
NX < -16 ?
NO
-1 ≥ NX ≥ -16
1N
(ONE-BYTE, NEGATIVE)
YES
NX < -512 ?
NO
-17 ≥ NX ≥ -512
2N
(TWO-BYTES, NEGATIVE)
YES
NX < -16384 ?
NO
-513 ≥ NX ≥ -16384
3N
(THREE-BYTES, NEGATIVE)
YES
ERROR
(OUT-OF-RANGE)

PMB Encoding Processes

One-Byte Format (X-Component)

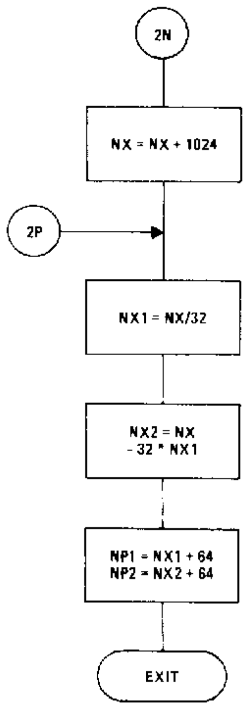
FLOW PROCESS



EXPLANATION	EXAMPLE
(From length calculations)	(Assume NX = -12)
Calculate decimal equivalent of the "Two's Complement" of NX.	NX = -12 + 32 = 20
(From length calculation)	
Assemble bits X_0 - X_4 into the parameter byte PX1. Set flag bits = "10" by adding 64.	NP1 = 20 + 64 = 84 PX1 = 1 0 1 0 1 0 0

Two-Byte Format (X-Component)

FLOW PROCESS



EXPLANATION	EXAMPLE
	(Assume NX = -385)
Calculate decimal equivalent of two's complement of NX.	NX = -385 + 1024 = 639.
Calculate decimal integer value of bits X_5 - X_9, to be assembled into parameter byte PX1.	NX1 = 639/32 = 19
Calculate decimal value of bits X_0 - X_4, to be assembled into parameter byte PX2.	NX2 = 639 - 608 = 31
Assemble the pre-calculated value portions of X into parameter bytes PX1, PX2. Set flag bits = "10" by adding 64 to each byte.	NP1 = 19 + 64 = 83 NP2 = 31 + 64 = 95 Assembled parameter: PX1 = 1 0 1 0 0 1 1 PX2 = 1 0 1 1 1 1 1

Three-Byte Format (X-Component)

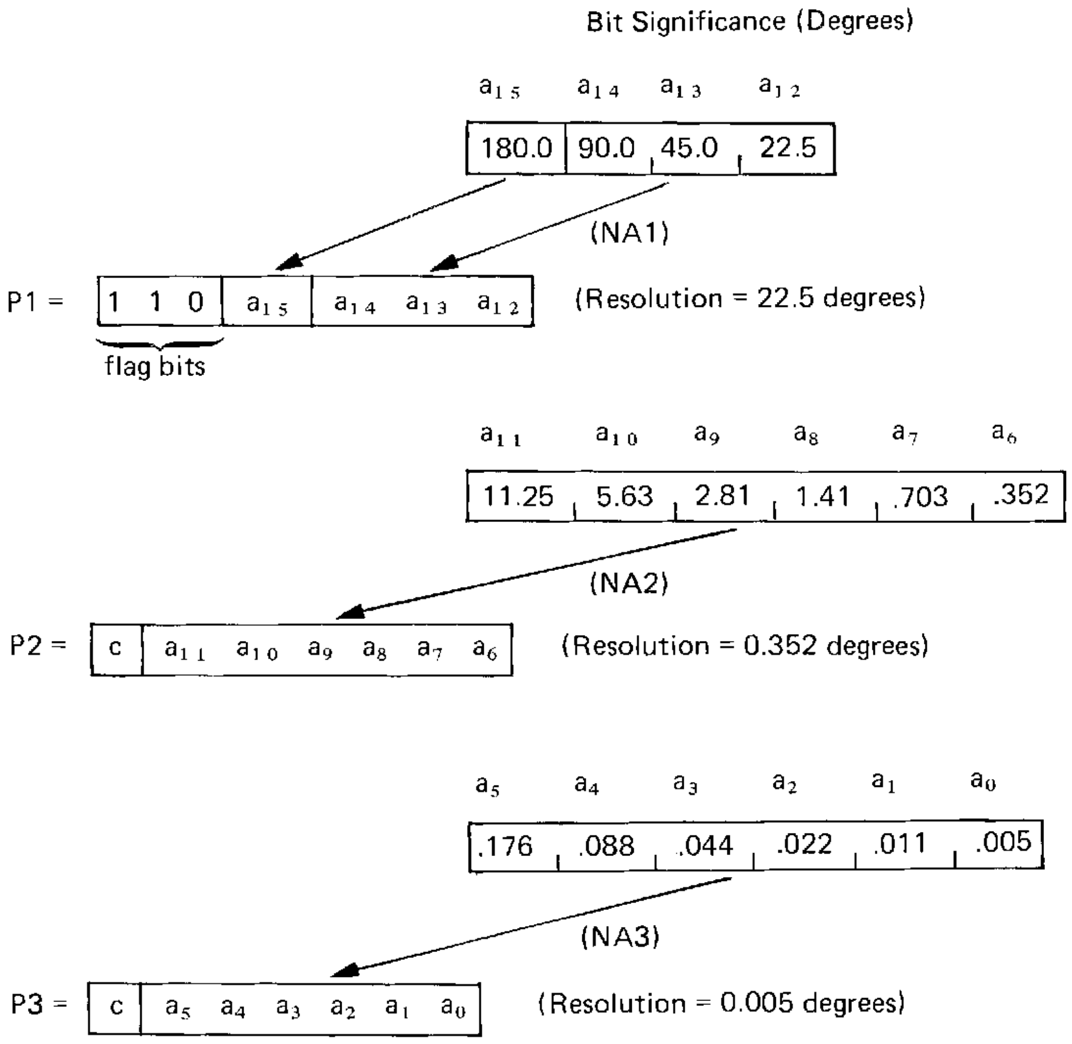
FLOW PROCESS	EXPLANATION	EXAMPLE
3N		(Assume NX = -16384)
NX = NX + 16384 NX = NX + 16384	Calculate decimal equivalent of the "2's complement" of NX, by adding 32768. (Shown in two steps, to avoid a number greater than 32767.)	NX = -16384 + 32768 = 16384
3P →		
NX1 = NX/1024	Calculate decimal integer value of bits X_{10} - X_{14}, to be assembled into byte PX1.	NX1 = 16384/1024 = 16
NXR = NX - 1024 * NX1	Calculate decimal value of bits X_0 - X_9.	NXR = 16384 - 16384 = 0
NX2 = NXR/32	Calculate decimal integer value of bits X_5 - X_9, to be assembled into byte PX2.	NX2 = 0
NX3 = NXR - 32 * NX2	Calculate decimal value of bits X_0 - X_4, to be assembled into parameter byte PX3.	NX3 = 0
NP1 = NX1 + 64 NP2 = NX2 + 64 NP3 = NX3 + 64	Assemble the pre-calculated value portions of X into the three parameter bytes. Set flag bits = "10" by adding 64 to each byte.	NP1 = 16 + 64 = 80 NP2 = 0 + 64 = 64 NP3 = 0 + 64 = 64
EXIT		Assembled Parameter PX1 = 1 0 1 0 0 0 0 PX2 = 1 0 0 0 0 0 0 PX3 = 1 0 0 0 0 0 0

Encoding Y-Components is identical except that the flag bits of each byte are set to "01" by adding 32 instead of 64.

The Multiple-Byte Angle (MBA)

This parameter expresses the size of an angle ranging from 0.0 to 359.995 degrees. The parameter may be from one to three bytes in length, depending on the magnitude and resolution of the value of the angle. Maximum resolution is 0.005 degrees. All angle values are considered positive, measured counterclockwise with respect to the "3 o'clock" position.

Format and Bit Assignments



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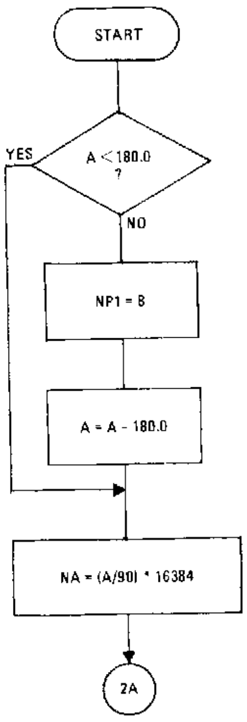
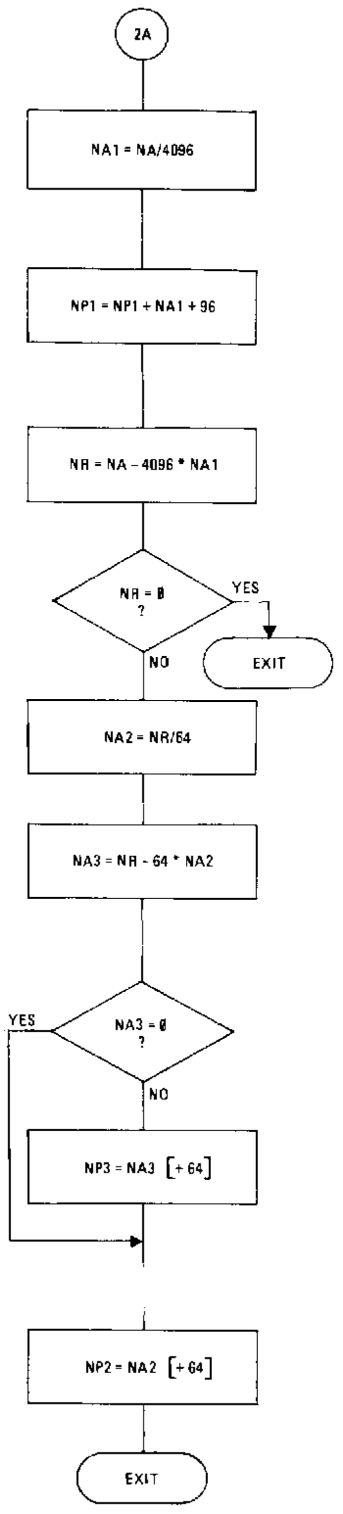
MBA Encoding Process

In the following process, the specified value of angle "A" is assumed to be less than 360 degrees. The modulo 180 value of the angle (in floating-point degrees) is calculated and transformed to a positive integer in the range of 0 to 32767. The integer's binary bits a_0 - a_{14} have the significance indicated in the foregoing format diagram. The integer is then assembled into the parameter by an algorithm similar to that used for the three-byte format of the Multiple-Byte Number (MBN), except that only the minimum number of bytes required to faithfully represent the angle are encoded. Bit a_{15} is encoded separately if A $\leqslant$ 180 degrees, in order to avoid creating an integer greater than 32767.

<table>
<tr><th>PROCESS FLOW</th><th>EXPLANATION</th><th>EXAMPLE</th></tr>
<tr><td rowspan="3">
</td><td></td><td>(Assume A = 300.0 degrees)</td></tr>
<tr><td>If angle A $\geqslant$ 180.0 degrees, set bit a_{15} = 1 in parameter byte P1, and calculate modulo 180 value of the angle.</td><td>NP1 = 8
P1 = $\boxed{0\ 0\ 0\ 1\ 0\ 0\ 0}$
A = 300 - 180 = 120.0</td></tr>
<tr><td>Transform modulo 180 value in degrees to a positive integer, 0 to 32767, whose binary bits are a_0 - a_{14}.</td><td>$NA = \frac{120.0}{90.0} * 16384$
NA = 21845</td></tr>
</table>

PROCESS FLOW



EXPLANATION	EXAMPLE
(continued)	
Calculate decimal integer value of bits a_{12} - a_{14}, to be assembled into the parameter byte P1.	NA1 = 21845/4096 = 5
Assemble value of a_{12} - a_{14} into the parameter byte P1. Set flag bits = "110" by adding 96.	NP1 = 8 + 5 + 96 = 109 P1 = 1 1 0 1 1 0 1
Calculate decimal value of bits a_0 - a_{11}.	NR = 21845 - 4096 * 5 NR = 1365
Is parameter complete with one byte?	
Calculate decimal integer value of bits a_6 - a_{11}, to be assembled into parameter byte P2.	NA2 = 1365/64 = 21
Calculate decimal integer value of bits a_0 - a_5, to be assembled into parameter byte P3, if necessary.	NA3 = 1365 - 64 * 21 NA3 = 21
Is parameter complete with two bytes?	
Assemble pre-calculated value of bits a_0 - a_5 into parameter byte P3. (Set complement bit by adding 64, if NA3 < 32.)	NP3 = 21 + 64 = 85 P3 = 1 0 1 0 1 0 1
Assemble pre-calculated value of bits a_6 - a_{11} into parameter byte P2. (Set complement bit by adding 64, if NA2 < 32.)	NP2 = 21 + 64 = 85 P2 = 1 0 1 0 1 0 1 Assembled Parameter P1 = 1 1 0 1 1 0 1 P2 = 1 0 1 0 1 0 1 P3 = 1 0 1 0 1 0 1

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Chapter 10
Instruction Set

Introduction

This chapter describes the complete Model 7221B and S Instruction Set. The chapter is organized by functional groups as follows:

Device Control Instructions

- I/O Control Group Instructions
- Output Group Instructions

Graphic Instructions

- Setup Group Instructions
- Plot Group Instructions
- Label Group Instructions
- Macro Instruction Group
- Paper Advance Group Instructions (7221S only)

A convenient foldout at the rear of the manual (Appendix E) provides ready reference to the Instruction Set. In this chapter and in Appendix E, the following syntax conventions apply:

< >	Numeric parameters are shown between angle brackets. These include decimal digits <DEC>, ASCII-encoded digits <ASC>, and binary-coded parameters such as multiple byte numbers <MBN>. Refer to Chapter 9 for descriptions of binary format.
[ ]	Optional parameters are shown between square brackets .
{ }	Parameters which may be repeated are shown between braces.
@	Literal bytes are represented by encircled equivalent ASCII characters. Refer to Appendix D to find the binary, octal and decimal values of these bytes.

Device Control Instructions

The Device Control instructions are acted upon immediately by the plotter, subject to relevant internal conditions, and are never stored in the plot data buffer. These instructions are arranged into two groups that are summarized below.

I/O Control Group

- Plotter On
- Plotter Off
- Set Output Mode
- Set Handshake Mode 1
- Set Handshake Mode 2
- Set Extended Output and Handshake Modes
- Set Plotter Configuration
- Abort Device Control Instructions
- Abort Graphic Instructions

Output Group

- Output Identification
- Output Buffer Size
- Output Buffer Space
- Output Status
- Output Error
- Output Graphic Limits
- Output Current Position
- Output Digitized Point
- *Output Extended Status

NOTE

All Device Control Instructions are three-character escape-code sequences. All two-character escape code sequences other than ESC . are completely ignored.

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*NOTE

This instruction pertains primarily to the 7221S plotter. However, if this instruction is sent to a 7221B, the plotter will output that the paper advance option is "off" (not pertinent).

I/O Control Group Instructions

Plotter On

ESC . (

Description: Beginning with the next character, the plotter intercepts incoming data and interprets it as plotter instructions, without passing it onto the terminal. However, the PLOTTER ON instruction itself will be passed onto the terminal as shown in Figure 10-1. If the plotter is already programmatically on, then a PLOTTER ON instruction is ignored. Refer to Chapter 3 for further information on operating modes.

Plotter Off

ESC .)

Description: Beginning with the next character, the plotter resumes a passive state in which data is passed both ways between the modem and terminal ports. The plotter will remain in this state until receipt of a PLOTTER ON instruction.

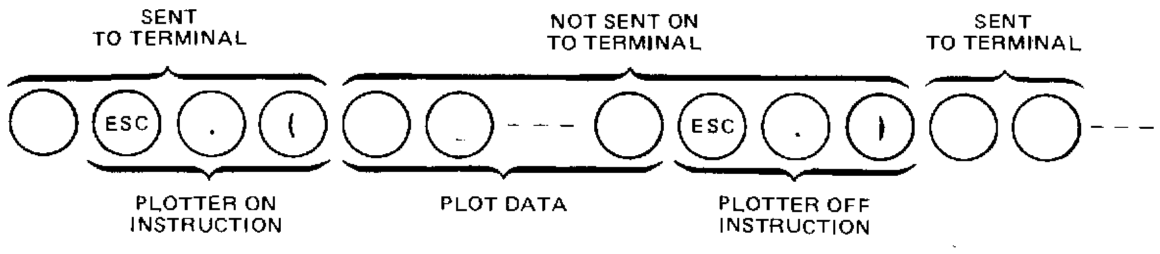

Figure 10-1. PLOTTER ON and PLOTTER OFF Instruction Routing, ON-LINE Mode

The <DEC> and <ASC> Formats

The next five instructions (Set Output Mode, Set Handshake Mode 1, Set Handshake Mode 2, Set Extended Output & Handshake Modes, and Set Plotter Configuration) have parameters which are not encoded in the binary format used with graphic instructions. Instead, these parameters are strings of decimal and ASCII-encoded digits separated by semi-colons. Each of these instructions is terminated by a colon which may occur after any number of parameters. Also, any parameter may be omitted by sending only the semi-colon which normally delimits it from the next parameter. Omitted parameters are set to their default values. Where the <ASC> format is used to specify the ASCII decimal equivalent of an input/output character, a "0" (the ASCII equivalent of NULL) generally indicates the associated function is not to be used. The <DEC> format is used to represent the ASCII decimal equivalent of an integer value. The following examples of the <DEC> and <ASC> formats define valid and invalid conditions.

Valid Formats.

ESC . M <DEC> :	All but first parameter defaulted.
ESC . M <DEC> ; ; ; ; <ASC> :	Second, third, and forth parameters defaulted.
ESC . H :	All parameters defaulted.

Invalid Formats.

ESC . H SPACE :	Embedded space.
ESC . I <DEC>	No terminating colon.
ESC . I <DEC> <ASC> <ASC> :	Missing semi-colon delimiters.

Set Output Mode

ESC . M [[<DEC>] ; [<ASC>] ; [<ASC>] ; [<ASC>] ; [<ASC>]] :

<DEC>	Turn-around delay (0 to 9999 milliseconds)
	Default: 0 milliseconds (no delay)
<ASC>	Output trigger character;ASCII decimal equivalent (0 to 126)
	Default: 0 (ASCII equivalent of NULL)
<ASC>	Echo-terminate character;ASCII decimal equivalent (0 to 126)
	Default: 0 (ASCII equivalent of NULL)
<ASC> <ASC>	Output terminator; 1 or 2 characters; ASCII decimal equivalents (0 to 127)
	Default: 13; 0 (ASCII equivalents of Carriage Return and NULL)

DEFAULT: ESC . M : is the same as

ESC . M 0 ; 0 ; 0 ; 13 ; 0 :

General Description

The SET OUTPUT MODE instruction establishes the nature of plotter outputs, providing compatibility with a wide variety of terminal protocols. Figure 10-2 illustrates the flowchart for a plotter output operation upon receipt of a SET OUTPUT MODE instruction.

Trigger

Beginning with the receipt of an output instruction and continuing until receipt of the trigger character, all input except device control instructions is ignored. If the trigger character is defaulted or specified as zero (NULL character), then a trigger is not required and input is not ignored.

Turn-Around Delay

Following receipt of the output instruction and trigger character (if any) the turn-around delay begins at the end of which time transmission begins.

Echo Terminate

Beginning with the start of transmission and continuing until receipt of the echo-terminate character, all input except device control instructions is ignored. If the echo-terminate character is defaulted or specified as zero (NULL character), then an echo-terminate character is not required and input is not ignored.

In the default situation, the plotter transmits requested information terminated by a carriage return, immediately following receipt of an output instruction.

Output Terminator

Following transmission of the requested information, the two terminator characters are transmitted. If the first character, or both characters are defined as zero (NULL character), then no terminator characters are transmitted. If the second character is defined as zero, then only the first character is transmitted. If the output terminator is defaulted, then only a carriage return is transmitted.

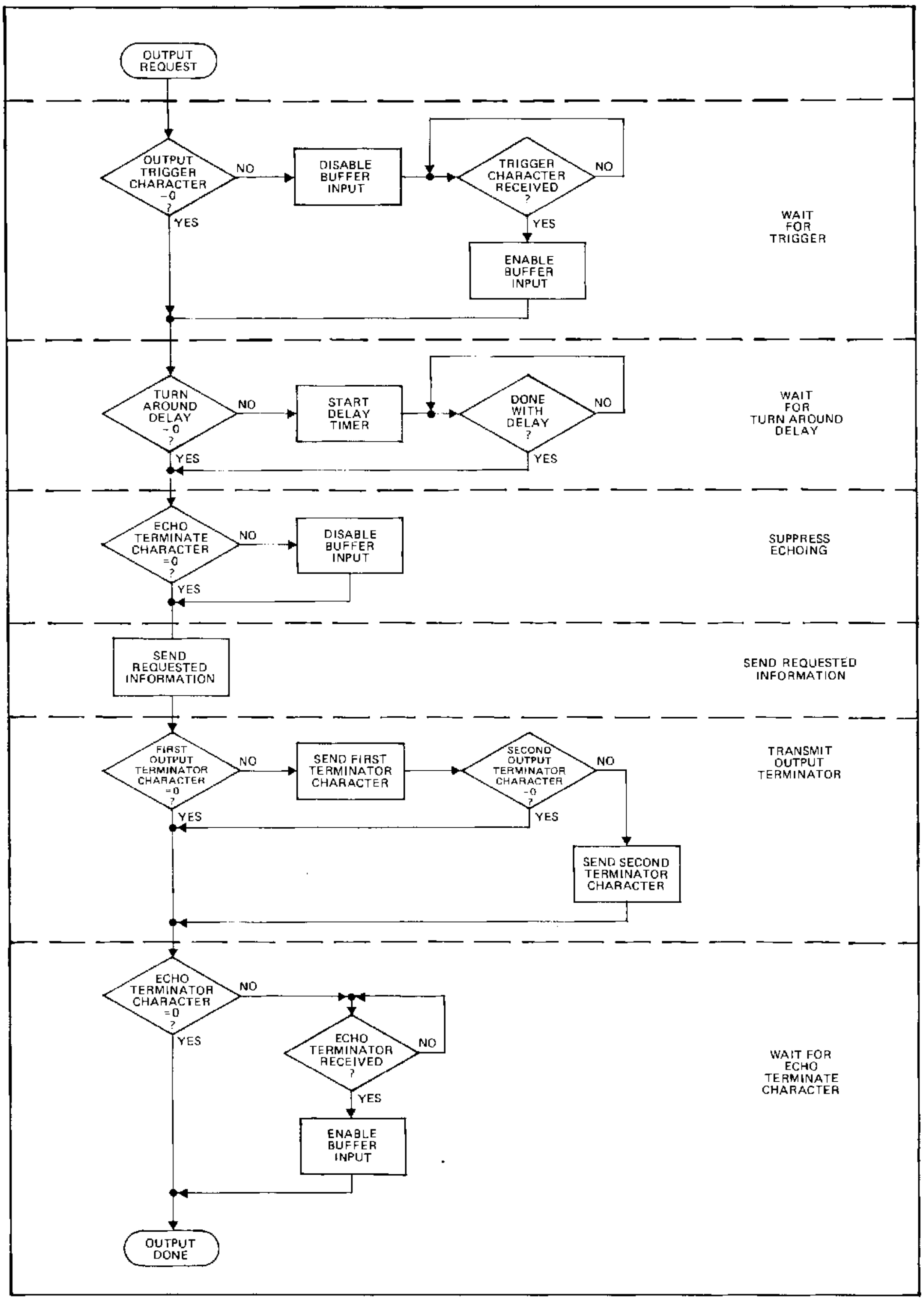

Figure 10-2. Plotter Output Mode Flowchart

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Set Handshake Mode 1

ESC . H [<DEC>] ; [<ASC>] ; {<ASC>} :

Set Handshake Mode 2

ESC . I [<DEC>] ; [<ASC>] ; {<ASC>} :

<DEC>	Block size (0 to 9999 bytes) Default: 0 bytes (80 bytes when bit 0 of the second parameter of the SET PLOTTER CONFIGURATION instruction is set equal to 1).
<ASC>	Handshake enable character-ASCII decimal equivalent (0 to 126) Default: 0 (ASCII equivalent of NULL)
{<ASC>}	Handshake string of 1 to 10 characters-ASCII decimal equivalent (0 to 127) separated by semi-colons Default: All 0 (ASCII equivalents of NULL)
DEFAULT:	ESC . H :
or	ESC . I :
is the same as	ESC . H 0 ; 0 ; 0 : if MODEM/HARDWIRE switch is set to MODEM at plotter power on.
and the same as	ESC . H 8 0 ; 0 ; 0 : if MODEM/HARDWIRE switch is set to HARDWIRE at plotter power on.

Set Extended Output and Handshake Mode

ESC . N [[<DEC>] ; {<ASC>}] :

<DEC>	Delay between output characters (0 to 9999 milliseconds) Default: 0 milliseconds (no delay)
{<ASC>}	Immediate response string to handshake enable character. String of 1 to 10 characters-ASCII decimal equivalents (0 to 127) separated by semi-colons Default: All 0 (none defined)
DEFAULT:	ESC . N :
is the same as	ESC . N 0 ; 0 :

General Description

The Set Handshake Mode 1, Set Handshake Mode 2, and Set Extended Output and Handshake Mode instructions establish an automatic handshake with which the plotter can indicate that buffer space is available for another block of graphic instructions and permits injecting a delay prior to each output character. Each handshake cycle is initiated by receipt of the handshake enable character as shown in Figure 10-3. The plotter then monitors the buffer until buffer space equal to or greater than the specified block size is available, at which time the handshake string is transmitted. If an immediate response string is specified, the string is transmitted prior to the handshake string. The immediate response and handshake strings consist of the first 1 to 10 non-NULL specified characters. A specified NULL character is not transmitted and terminates the string.

Handshake Mode 1

In this mode, the handshake string is transmitted in accordance with the conditions established by the SET OUTPUT MODE and SET EXTENDED OUTPUT AND HANDSHAKE MODE instructions, which may include turn-around delay, character delay, trigger character, echo-terminate character, and output terminate characters.

Handshake Mode 2

In this mode, transmission of the handshake string is not subject to the trigger character, echo-terminate character, and output terminate character conditions established by the SET OUTPUT MODE instruction. The handshake string is transmitted as soon as buffer space is available, but after the character delay, turn-around delay, and immediate response string, if specified.

Modes 1 and 2

Unless otherwise specified by modes 1 or 2, the receipt of an ENQ control character causes transmission of an ACK character. This is an automatic "dummy" handshake which is not dependent on buffer space and will only occur if a received ENQ character is not used for some other function.

The two handshake modes are mutually exclusive. Specifying either mode will disable the other mode such that only one mode is in effect at a time.

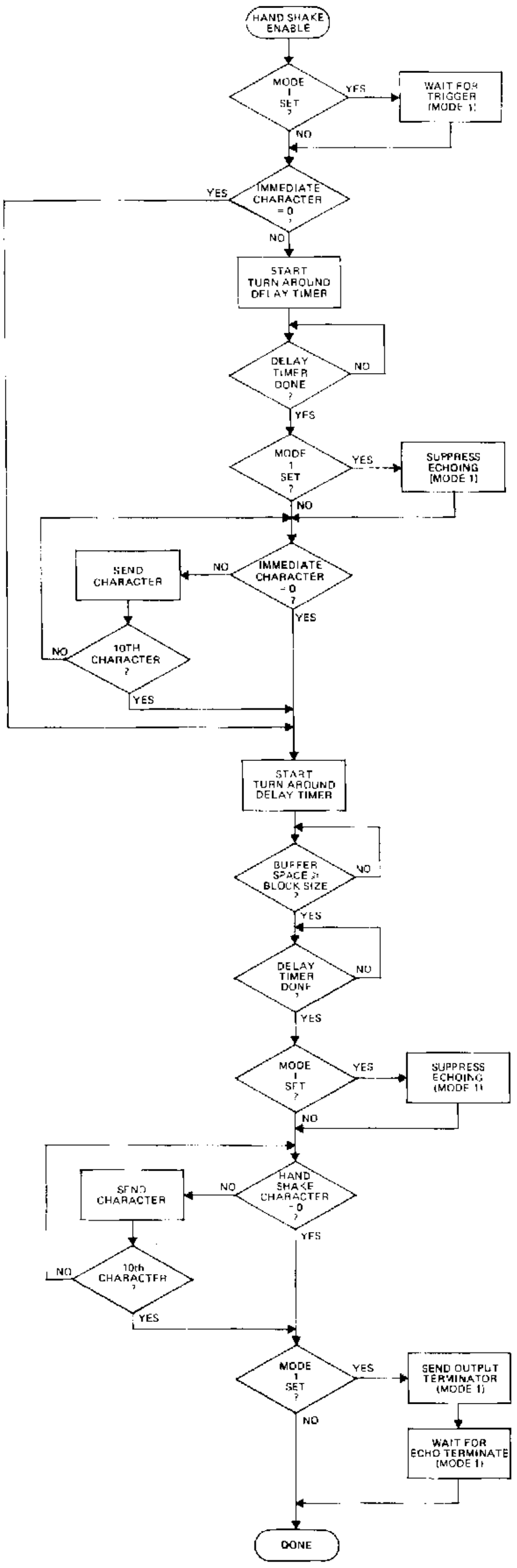

Figure 10-3. Plotter Handshake Mode Flowchart

Extended Output

The first parameter of the Set Extended Output and Handshake Mode establishes a delay prior to the output of each character. If a character delay is specified, each "SEND CHARACTER" block in Figure 10-3 is expanded to reflect the flowchart shown in Figure 10-4.

Handshake Mode

The second parameter of the Set Extended Output and Handshake Mode identifies an immediate response string which is transmitted in accordance with the conditions established by either Set Handshake Mode 1 or Mode 2 as shown in Figure 10-3.

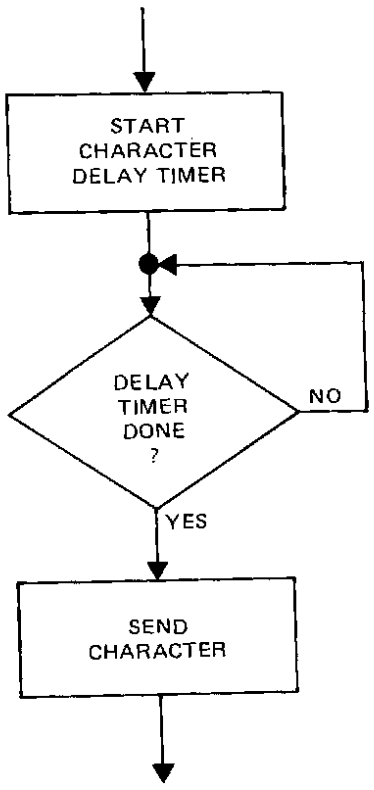

Figure 10-4. Character Delay Flowchart

Set Plotter Configuration

ESC . @ [[<DEC>] ; [<ASC>]] :

<DEC>	Set maximum buffer size (0 to 9999 characters)
	Default: Maximum actual buffer in the plotter
<ASC>	Set configuration options character-ASCII decimal equivalent of 4-bit word (0 to 15): The ASCII decimal equivalent of a 7-bit word is possible; however, the three most significant bits are not used.
	Default: Initialized only at plotter power on. Bit 0 and bit 1 determined by position of MODEM/HARDWIRE switch: MODEM = 0; HARDWIRE = 1. Bit 2 and bit 3 = 0
DEFAULT:	ESC . @ :
is the same as	ESC . @ 1 1 2 8 ; 0 : if MODEM/HARDWIRE switch is set to MODEM.

Description

The first parameter of this instruction sets the apparent maximum buffer size and available space of the plotter to help ensure that graphics data does not overflow the buffers capacity. The actual buffer size and space are unchanged, but the plotters response to an output request for buffer size or buffer space is restricted to a value equal to or less than the value specified by the first parameter of this instruction. The second parameter establishes configuration options as defined by the bit pattern listed in Table 10-1.

Table 10-1. Set Configuration Options Bit Definition

BIT	LOGIC STATE	DESCRIPTION
0	0 (off)	Sets RS-232-C Data Terminal Ready (CD) control line to high (on) at modem connector as required for normal control line protocol. Refer to Figure 11-4.
	1 (on)	Establishes "Buffer Available Flag" at modem connector on RS-232-C Data Terminal Ready (CD) control line, where (CD) is not normally used in a hardwired environment. Refer to Figure 11-4. (CD) is set high (on) if: Buffer space > = current block size. The block size is established by the SET HANDSHAKE MODE 1 or MODE 2 instructions, and unless otherwise specified, the block size will default to 80 bytes when bit 0 of this instruction is set to 1 or if the MODEM/HARDWIRE switch was set to HARDWIRE at plotter power-up. (CD) is set low (off) if: Buffer space < current block size.
1	0 (off)	Implements "Disable Data Transmission" as shown in Figure 11-4. Normal control line protocol must be observed in order for data transmission to occur.
	1 (on)	Enables data transmission independently of the RS-232-C Data Set Ready (CC) and Clear To Send (CB) control line conditions as shown in Figure 11-4.
2	0 (off)	Allows STBY indicator lamp to be lit only when plotter is in STANDBY mode.
	1 (on)	Causes STBY indicator lamp to flash if a character has been sent to the plotter within the last ¼ second. This visual indication that data is being sent to the plotter is available only when programmed "on" in the On Line or Local mode.

Table 10-1. Set Configuration Options Bit Definition (Continued)

BIT	LOGIC STATE	DESCRIPTION
3	0 (off)	Allows plotter to operate normally, as specified for the ON LINE programmed "on" mode.
	1 (on)	Enables all data that is received or transmitted by the plotter to be viewed on the terminal. This is called "MONITOR" mode and is active only when the plotter is programmed "on" in the On Line mode. All data which the terminal sends to the plotter (except "Break") is ignored while in "MONITOR" mode. NOTE All data is transmitted to the terminal in the following ways: a. Data received by the plotter at the modem connector is also sent to the terminal connector. b. When the DUPLEX switch is set to HALF, all plotter output responses are sent to both the computer and terminal. c. When the DUPLEX switch is set to FULL, all plotter responses are sent to the computer. If the computer is working in an echo plex environment, each of the plotters output responses is then echoed from the computer, through the plotter, to the terminal.

10

Abort Device Control Instruction

ESC . J

Description

This instruction aborts any Device Control instructions that may be partially decoded or executed. Unspecified parameters of partial instructions are defaulted. All pending or partially transmitted output requests are immediately terminated including digitize, handshake and output instructions. Intermediate output operations, such as turn-around delay and echo suppression, are aborted and buffer input is enabled. Only the specified execution of an output operation is aborted. The handshake and output modes remain as specified. When a digitize operation is aborted, the ENTER light is turned off and the execution of graphic instructions is resumed.

Abort Graphic Instruction

ESC . K

Description

This instruction aborts any partially decoded Graphic instructions but permits instructions being executed to finish. All pending Graphic instructions in the buffer are discarded, leaving the buffer empty. Partially defined macroinstructions are completely erased, although all other macros remain as defined. Partially executed macro-invokes and labels are terminated.

Output Group Instructions

All output instructions operate according to conditions established by the previously described SET OUTPUT MODE instruction and are also subject to the output character delay as established by the SET EXTENDED OUTPUT AND HANDSHAKE MODE instruction. All output parameters consist of ASCII digits, minus signs and commas that form integers in the range between -32768 and 32767 which are delimited by commas. Leading zeros and plus signs are not sent.

Output instructions are not stored in the plotter's buffer, and processing begins as soon as they are received. Therefore, the requested outputs reflect current conditions in the plotter.

Error 10 is set in the plotter if an output request instruction is received while a previous output request is being processed.

Output Identification

ESC . A

Response:

7221,<date code>,<ROM option>

Response Description:

7221	Model Number
<date code>	Firmware date code, 3 to 5 digits
<rom option>	Plug-in ROM option code, 0 = none

Output Buffer Size

ESC . L

Response:

<bytes>

Response Description:

<bytes>	Number of bytes allocated to buffer use; 0 to 1128 bytes. (0 to 3056 bytes with the additional R/W memory option.)

Description

The number of bytes allocated to buffer use is equal to the total amount of user R/W memory (1128 or 3056 bytes), minus the amount currently allocated to macros. In addition, the response will not be transmitted until the buffer is empty, so that the size will also equal currently available buffer space. The response may be restricted to a maximum value established by the SET PLOTTER CONFIGURATION instruction. Refer to Chapter 3 for a discussion of buffer implementation.

Output Buffer Space

ESC . B

Response:

<bytes>

Response Description:

<bytes>	Number of bytes of buffer space that are currently available for storing received graphic instructions. 0 to 1128 bytes in the standard instrument, and 0 to 3056 bytes with the additional R/W memory option.

Description

The number of currently available bytes in the buffer equals the buffer size minus the number of bytes occupied by the graphic instructions yet to be executed. The response may be restricted to a maximum value established by the SET PLOTTER CONFIGURATION instruction.

Output Status

ESC . F

Response:
<status>

Response Description:
<status> Decimal equivalent of 16 bit status word -32768 to 32767

Description

This instruction response provides the status of the plotter using the bit pattern listed in Table 10-2. Bits 0 to 7 contain information about the plotter's pens. Bits 8 to 10 indicate operational states, and bits 11 to 15 indicate occurrence of events that may effect plotting. Bits 11 to 15 are reset to 0 after each OUTPUT STATUS instruction. Immediately after plotter power on bits 0 to 3, bit 8, bit 10 and bits 13 to 15 are initialized to 0; bits 9, 11 and 12 are initialized to 1; and bits 4 to 7 indicate pens in the pen stalls.

PROGRAMMING NOTE

Some conditions which cause a status bit to be set "on", will also later cause an error to be set when the data involved is being processed for execution. Examples of this are buffer overflow (status bit 12) and transmission errors (status bit 14). The OUTPUT STATUS instruction provides a means of periodically checking the validity and integrity of data sent to the plotter, without waiting for that data to be processed for execution.

Table 10-2. Output Status Bit Definition

BIT	DECIMAL EQUIVALENT	DESCRIPTION
		– PEN CONDITIONS –
0	1	Pen Up/Down (0/ 1)
1	2	
2	4	
3	8	
		0 0 0 NO PEN SELECT instruction since power on, or no pen in holder
		0 0 1 Pen 1 in holder
		0 1 0 Pen 2 in holder
		0 1 1 Pen 3 in holder
		1 0 0 Pen 4 in holder
4	16	Pen Stall No. 1 Empty/Occupied (0 / 1)
5	32	Pen Stall No. 2 Empty/Occupied (0 / 1)
6	64	Pen Stall No. 3 Empty/Occupied (0/ 1)
7	128	Pen Stall No. 4 Empty/Occupied (0 / 1)
		– OPERATIONAL STATES – NO = 0 YES = 1
8	256	Pause in graphics while front panel is being serviced
9	512	Logical pen position is currently out of limits (OUT OF LIMITS light is on steady)
10	1024	Macro instruction is being defined and stored

Table 10-2. Output Status Bit Definition (Continued)

BIT	DECIMAL EQUIVALENT	DESCRIPTION
		– ADVISORY CONDITIONS – NO = 0 YES = 1
11	2048	Plot variables have been altered by front panel operator controls. This bit is set when the following occurs: Power On Front panel initialize Front panel operation of: UPPER RIGHT LOWER LEFT CHART LOAD Arrow/FAST pushbuttons These controls can be used to change the pen position or graphic limits, and their use will set bit 11 whether or not the associated variables have new values. Bit 11 will not be set by operator (front-panel) changes in pen status (up or down).
12	4096	The data buffer has overflowed or has been flushed (emptied). Bit 12 is set when there is no room in the buffer for a received character. Refer to the Chapter 3 discussion covering buffer implementation and the section entitled "Transmission Errors" in Chapter 11. The buffer is also flushed and bit 12 set when one of the following events occur: The front-panel STBY (standby) control is operated. When an ABORT GRAPHIC instruction is executed.

Table 10-2. Output Status Bit Definition (Continued)

BIT	DECIMAL EQUIVALENT	DESCRIPTION
		– ERROR CONDITIONS – (Refer to the OUTPUT ERROR instruction for further information concerning the types of errors). NO = 0 YES = 1
13	8192	Syntactical error has been detected and the ERROR light is on. A syntactical error means that input data contains invalid instructions or formats or that an instruction has been illegally used.
14	16384	A transmission error has occurred, such as a parity error, causing input data to be improperly received. Bit 14 is set when a bad byte is received; however, a syntactical error will not be recorded, nor the front-panel ERROR lamp lighted, until the bad byte is being processed for execution.
15	Sign	An internal error has occurred and the ERROR light is blinking. The plotter has detected an error in the execution of the internal firmware which is generally due to a transient or permanent hardware failure. The plotter treats this type error like any other, except that it also reestablishes certain critical internal variables. Refer to Chapter 2 for details on the "Confidence Test."

Output Error

ESC . E

Response:
<type>, <byte>, <quantity>

Response Description:

<type>	Error type of most recent error, 0 to 99
<byte>	Byte, instruction, or macro in which error occurred, 0 to 126
<quantity>	Number of errors since last OUTPUT ERROR instruction, 0 to 32767

Description

This instruction responds with information concerning the most recent error. If no errors have occurred the plotter will output 0, 0, 0. The types of plotter errors are listed in Table 10-3. For error types 1, 2 and 3 the <byte> output is the ASCII decimal equivalent of the invalid byte. For error types 5 through 8, 10, 11, 20 and 99 the <byte> uniquely identifies the instruction in which the error occurred. In graphic instructions this byte is the first byte of the instruction unless the byte is a ~ . In this case, the <byte> response identifies the second byte. In Device Control instructions, the <byte> response is the character following ESC . . For error types 13 through 19, the <byte> response identifies the number of the affected or indicated macro instruction.

The <quantity> response is the number of errors since power on, or since the last OUTPUT ERROR instruction. This number cannot exceed 32767.

In general, when an error is encountered, the instruction in which the error occurred is aborted. When the instruction is a graphic instruction, all buffer data will be ignored without further errors until the valid first byte of a grpahic instruction is received. Error conditions existing in a graphic instruction do not result in setting an error in the plotter until that instruction is being processed for execution.

After completion of an OUTPUT ERROR instruction, the front-panel ERROR light is cleared and all three error items are reset to zero. The associated status bit remains unchanged.

Table 10-3. Output Error Types

<TYPE>	DESCRIPTION
0	No errors.
1	Invalid byte received when graphic instruction expected.
2	Invalid byte received following the ~ in a graphic instruction.
3	Invalid byte received following the ESC . in a device control instruction.
4	Out of paper or paper advance option is "off" when either ~ + or ~ - instruction is received.
5	Missing Y part in an INCREMENTAL MOVE or DRAW instruction, or missing length parameter in the DASH LINES instruction.
6	Parameter out-of-range (too big, too small or an illegal value).
7	Too many bytes in a multi-byte parameter.
8	Too many space/dash parameters in a DASH LINES instruction. Too many <ASC> parameters in a SET OUTPUT MODE instruction. Too many <ASC> parameters in a SET HANDSHAKE MODE 1 or 2 instruction.
9	Not used.
10	Output instruction received while another output instruction is executing. The original output instruction will continue normally while the one in error will be ignored.
11	A LABEL instruction contains a character which has one or more out-of-range vectors due to large size and/or slant. When the first out-of-range vector is detected, the character is aborted and the next character is attempted.

Table 10-3. Output Error Types (Continued)

<TYPE>	DESCRIPTION
12	Not used.
13	An AUTOMATIC MACRO instruction has been encountered within an automatically invoked macro.
14	An AUTOMATIC MACRO instruction has specified a non-existent macro.
15	A MACRO INVOKE instruction has specified a non-existent macro.
16	A MACRO INVOKE instruction has attempted an invoke of itself either directly, or indirectly through other macros.
17	A MACRO DEFINE instruction has been attempted within a MACRO DEFINE instruction.
18	A MACRO DEFINE instruction has attempted to define a macro which is bigger than the available space. The entire macro has been erased and ignored.
19	A transmission error has occurred to a byte in a MACRO DEFINE instruction. The entire macro has been erased and ignored.
20	A transmission error has been detected in a graphic instruction other than a MACRO DEFINE instruction.
99	An internal error has been detected, and the front-panel ERROR light is flashing.

Output Graphic Limits

ESC	.	G

Response:

<X min>,<Y min>,<X max>,<Y max>

Response Description:

<X min>,<Y min>	Lower left graphic limit point in machine units, 0,0 to 16000, 11400
<X max>,<Y max>	Upper right graphic limit point in machine units, 0,0 to 16000, 11400

Description

Outputs the current lower left and upper right graphic limit points as established by use of front-panel controls, a set GRAPHIC LIMIT instruction, or an initialize operation. Refer to Chapter 4 for a definition of machine units.

NOTE

Graphic limit points are established differently on the 7221S, and depend on whether "English" or "Metric" size roll paper is loaded in the plotter.

Output Current Position

ESC . C

Response:

<X position>,<Y position>,<pen>,

Response Description:

<X position>	X coordinate of pen position in machine units, 0 to 16000
<Y position>	Y coordinate of pen position in machine units, -968 to 11400
<pen>	Pen state UP/DOWN (0/ 1)

Description

The current pen position is output unless the pen is moving along a programmed vector, in which case the end point is output (i. e., soon to be current position). The Y coordinate is negative when the pen holder is in the stable area. Immediately after power-on or an initialize operation, the current position is undefined until the mechanical limits have been established.

PROGRAMMING NOTE

Normally, in order for the plotters' response to be meaningful, all previous graphic data in the buffer should be executed prior to sending the OUTPUT CURRENT POSITION instruction. The following sequence will ensure this condition.

Send:	;	Instruction terminator (ensures that last instruction is executed).
	ESC . L	OUTPUT BUFFER SIZE instruction (waits for buffer to be emptied).

[Read Buffer Size to determine if all data in buffer is executed] .

ESC . C	OUTPUT CURRENT POSITION instruction.

Output Digitized Point

ESC . D

Response:

<X position>,<Y position>,<pen state>,<pen number>

Response Description:

<X position>	X coordinate of digitized point in plotter units, 0 to 16383.
<Y position>	Y coordinate of digitized point in plotter units, 0 to 16383.
<pen state>	Pen UP/DOWN (0 / 1) at digitized point.
<pen number>	Selected pen number at digitized point; 1 through 4 or 0 (none).

Description

Receipt of this instruction starts a digitize operation. The ENTER light comes on steady and the operator moves the pen to the desired position using the front-panel arrow push-button controls. As usual, the pen only comes to rest on grid intersections so that the grid resolution determines digitizing resolution. The operator may also select any pen and set it up or down. The operator then operates the ENTER switch which causes the digitized point to be transmitted, the ENTER light to go out, and the digitize operation to terminate.

Each digitize operation must be initiated by receipt of an OUTPUT DIGITIZED POINT instruction. Note that the digitized point is output in plotter (grid-defined) units and that points outside the graphic limits can not be digitized. Attempts to digitize a point when the OUT OF LIMIT light is on, are ignored. Refer to Chapter 4 for a definition of plotter units.

PROGRAMMING NOTE

Normally, point digitizing is implemented after all pending graphic instructions are executed (buffer empty). To accomplish this, the OUTPUT DIGITIZED POINT instruction may be preceded by an instruction terminator and an OUTPUT BUFFER SIZE instruction, as shown in the programming note under OUTPUT CURRENT POSITION.

Output Extended Status

(ESC) (.) (O)

Response: <status>
Response Description: <status> Decimal equivalent of 2 bit status word in the range of 0 to 3.

Description

This instruction response provides the status of the 7221S paper advance option using the bit pattern listed in Table 10-4. The instruction is relevant to the 7221B only to indicate that the paper advance option is "off" (not used).

PROGRAMMING NOTE

This instruction can be used at the beginning of a plotting sequence to determine if a paper advance operation is necessary and feasible before plotting commences, and to check for an out-of-paper condition resulting from the paper advance. When requesting OUTPUT EXTENDED STATUS after a paper advance operation, it is necessary to ensure that the paper advance instruction is actually executed before requesting the extended status. The following sequence suggests one way to accomplish this.

Send:	(~) (+)	ADVANCE FULL PAGE instruction.
	(¦)	Instruction terminator.
	(ESC) (.) (L)	OUTPUT BUFFER SIZE instruction.
	[Read Buffer Size to determine if all data in buffer is executed].	
	(ESC) (.) (O)	OUTPUT EXTENDED STATUS instruction.

Refer to the Paper Advance Group Instructions for more details.

Table 10-4. Output Extended Status Bit Definition

BIT	LOGIC STATE	DESCRIPTION
0	0	Paper advance "off" (Roll paper is not loaded)
	1	Paper advance "on" (Roll paper is loaded)
1	0	Set only after an advance has happened and "paper" is sensed.
	1	Current page not clean. Set under the following conditions: a. At plotter power on. b. Each time pen is programmatically lowered. c. Each time "no paper" is sensed after a front panel paper advance. d. Each time "no paper" is sensed before a programmatic paper advance attempt or after a programmatic paper advance.
2 to 15	All 0	Not used.

The possible combinations of bits 0 and 1, and their significance, are shown in Table 10-5.

Table 10-5. Output Extended Status Bit Significance

BIT 1	BIT 0	SIGNIFICANCE
0	0	a. The paper advance feature is present. b.* A previous paper advance operation has successfully been completed, but roll paper has since been removed or the lid on one of the paper advance modules has been raised. c. The plotting pen has not been lowered since the last paper advance.
0	1	Same as both bits = 0, except that roll paper is still loaded and both lids are closed. Therefore, paper is "clean", and no paper advance is necessary.
1	0	The paper advance feature may or may not be present, but if so, there is no roll paper loaded or the lid on one of the paper advance modules is raised.
1	1	The paper advance feature is present, roll paper is loaded and both lids are closed, but one of the following conditions has occurred which would warrant a paper advance operation before any further plotting is attempted: a. The pen has been lowered (paper is dirty). b. No paper advance has been attempted since plotter power-up, therefore the "clean" or "dirty" status has not been established by the plotter. c. A previous paper advance operation resulted in detection of an out-of-paper condition, but roll paper has since been loaded.

*A paper advance operation is "successful" if it is initiated and completed without detecting an out-of-paper condition.

Graphic Instructions

Graphic instructions are always routed to the buffer and contain, in general, anything that affect the drawing being constructed by the plotter. All instructions are accessed from the buffer by a parser on a first in, first out basis. These instructions are arranged into five groups that are summarized below.

Setup Group

- Initialize
- Set Graph Limits
- Set Grid Size
- Velocity Select
- Arc Tolerance

Plot Group

- Pen Select
- Move
- Draw
- Incremental Move
- Incremental Draw
- Arc Clockwise/Counterclockwise
- Fixed/Variable Dash Lines
- Rotate
- Rotate at Last Angle

Label Group

- Label Mode On
- Set String Terminator
- Label Size
- Label Slant
- Label Font

Macro Instruction Group

- Macro Instruction Define
- Macro Instruction Invoke
- Automatic Macro Instruction

*Paper Advance Group

- Cutter Enable
- Cutter Disable
- Advance Full Page
- Advance Half Page

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*NOTE

These instructions pertain only to the 7221S Plotter.

Setup Group Instructions

These instructions are generally used at the beginning of a plotting session to establish the desired plotter configuration. Attempts to use the SET GRAPHIC LIMIT instruction as a general purpose window, or the SET GRID SIZE instruction as a general scaling instruction will meet with failure in most applications. The plotter was not designed to perform those functions in that manner.

Initialize

~ _

This instruction causes the plotter to find the mechanical limit switches thus resetting the mechanical origin. The plotter also resets all graphic variables to their default values, as well as clearing the ERROR light and error report variables. The status word is unaffected as are the device control variables (output mode, handshake mode, buffer data and macro data). Following an INITIALIZE instruction, graphic data is ignored until the valid first byte of a graphic instruction.

Set Graph Limits

~ W [<MBP> [<MBP>]]

<MBP> X,Y coordinates of the lower left point in machine units; 0,0 to 16000, 11400

<MBP> X,Y coordinates of the upper right point in machine units; 0,0 to 16000, 11400

Default: Upper right point maintains a constant position relative to the lower left point

7221B Default: Lower Left X,Y = 520, 380 machine units
Upper right X,Y = 15720, 10380 machine units

7221S Default: If paper advance is "off" same as 7221B

If paper advance is "on" and ENGLISH/METRIC switch is set to ENGLISH
Lower left X,Y = 520, 1020 machine units
Upper right X,Y = 15760, 11180 machine units

If paper advance is "on" and ENGLISH/METRIC switch is set to METRIC
Lower left X,Y = 520, 1140 machine units
Upper right X,Y = 15720, 11140 machine units

Description

Establishes the physical locations on the plotting surface that are used as the origin and full scale point for the plotter unit grid system. A plotter unit value of (0,0) is assigned to the specified location of lower left, and the full scale values as specified by the SET GRID SIZE instruction are assigned to the specified location of upper right. The location of the lower left and upper right can be interchanged as desired to invert or mirror the resulting plot. If no upper right parameter is included, then the upper right position "follows" the lower left position so as to maintain a constant relative distance. The upper right is permanently reset to the closest mechanical limits if a upper right parameter is specified or implied to be outside the limits. The pen cannot be programmatically moved beyond the graphic limits. Lines which are specified beyond the graphic limits are clipped and the pen lifted at the boundary. The OUT OF LIMIT lamp is lighted as long as the logical (presumed) position of the pen is beyond graphic limits.

Setting the graphic limits resets the logical position and moves the pen to the new grid point which is nearest the original physical location of the pen.

Set Grid Size

~ S [<MBP>]	
<MBP>	X max, Y max plotter units; 0, 0 to 16383, 16383 Default: 3040, 2000

Description

This instruction establishes the grid system in which all plotting occurs, and defines plotter units. The end points of all internally and externally generated lines are on the grid points. The defined grid system is mapped onto the graphic limits in such a manner that the plotter unit origin 0, 0 is mapped onto the Lower Left and the X max, Y max plotter unit point is mapped onto the Upper Right. Setting the grid size resets the logical pen position and moves the pen to the new grid point which is nearest the original physical location of the pen. Although plotter units can imply more precision, the plotter will round all plotter unit values to the nearest machine unit (.025 mm) before plotting.

NOTE

Default graphic limits and grid size parameters establish one plotter unit in either orthogonal direction as equivalent to five machine units (0.125 mm).

Velocity Select

~ V [<SBN>]	
<SBN>	Maximum axis velocity in cm/sec, 1 to 36 Default: 36 cm/sec

Description

This instruction sets the maximum velocity attainable in either axis. This velocity setting does not effect pen up moves or front panel operations. When the velocity is less than maximum (36 cm/sec), then the acceleration is automatically halved from 400 cm/sec/sec to 200 cm/sec/sec.

Arc Tolerance

~ T [<SBN>]

<SBN>	Tolerance in plotter units, 1 to 63
	Default: 1 plotter unit

Description

Sets the maximum deviation between a specified arc and the internally generated chords that are used to approximate that arc. The tolerance is specified in plotter units. Smaller tolerances cause smoother arcs to be drawn but, consequently, increase the plotting time for a given arc.

The number of straight line chords used to approximate an arc varies as a function of both the specified tolerance and the radius of the particular arc. As the tolerance is increased or the radius is decreased, the number gets smaller. A lower limit on the angle of the chords in an arc has been established at 45 degrees. This means that at least one chord will be drawn for each 45 degrees of arc regardless of the radius or current value of the tolerance.

Plot Group Instructions

Pen Select

v [<SBN>]	
<SBN>	Number of pen to be selected, 0—4 (0 = put current pen away)
	Default: Puts current pen away

Description

This instruction selects a pen from the indicated stall unless that stall is empty or the pen holder has a pen and there are no empty stalls. The plotter puts the current pen into the stall from which it came unless it is occupied, in which case the pen is put into the lowest numbered empty stall. If the plotter cannot perform the requested action, the instruction is ignored. After selecting a pen, the plotter returns to the original position with the pen up. Pen selection does not effect any other graphic instructions.

Move

p [<MBP> [{<MBP>}]]

<MBP>	Absolute X,Y end point of first pen-up move in plotter units; 0, 0 to 16383, 16383
{<MBP>}	One or more absolute X,Y end points of successive pen-down moves in plotter units; 0, 0 to 16383, 16383
	Default: Pen is left up after the first move if only one end point is specified
	Default: If no end points, then pen is raised with no change in position

Description

This instruction specifies a series of end points to which the plotter moves in succession, starting at the present position. The first move is done with the pen up, but all subsequent moves are done with the pen down. The end points are specified in absolute plotter units (i.e., relative to the lower left) and are subject to the grid size and graphic limits in effect at that time. Pen down moves are also subject to the current dash mode and pattern.

Draw

q [{<MBP>}]

{<MBP>}	One or more absolute X,Y end points of successive pen-down moves in plotter units; 0, 0 to 16383, 16383 Default: If no end points, then pen is lowered, regardless of out-of-limits condition or dash mode.

Description

This instruction is similar to the MOVE instruction except that all moves are done with the pen down, including the first move.

Incremental Move

r [<PMB> [{<PMB>}]]

<PMB>	Incremental X,Y displacement of first pen-up move in plotter units; -16384, -16384 to 16383, 16383
{<PMB>}	One or more incremental X,Y displacements of successive pen-down moves in plotter units; -16384, -16384 to 16383, 16383
	Default: Pen is left up after the first move if only one incremental displacement is specified
	Default: If no displacements are specified, then the pen is raised with no change in position

Description

This instruction is similar to the MOVE instruction except the moves are specified by displacements relative to the pen position prior to each move. In addition, INCREMENTAL MOVES are subject to the current rotation.

Incremental Draw

s [{<PMB>}]	
{<PMB>}	One or more incremental X,Y displacements of successive pen-down moves in plotter units; -16384, -16384 to 16383, 16383 Default: If no displacement specified, then pen is lowered, regardless of out-of-limit condition or dash mode

Description

Similar to the INCREMENTAL MOVE instruction except that all moves are done with the pen down, including the first move.

Arc Clockwise

t	[<MBN> [<MBA> [<MBA>]]]

Arc Counterclockwise

u	[<MBN> [<MBA> [<MBA>]]]

<MBN>	Radius of arc in plotter units, 1 to 32767 Default: Last radius received, if none received then OUT-OF-RANGE error is flagged
<MBA>	Start angle, in degrees, 0 to 359.995 Default: Start and stop angles are both assumed to be zero (3 o'clock position)
<MBA>	Stop angle, in degrees, 0 to 359.995 Default: Stop angle is assumed to be equal to the start angle (i.e., implies a circle)
	Default: Full circle plotted starting at zero degrees with a radius equal to last radius received

Description

Each of these two instructions causes an arc, approximated by a series of equal length straight-line chords, to be drawn from the current position to the implied end point, in the specified direction. All arcs are drawn with the pen down. If only a radius is specified, then a circle is drawn, starting and stopping at the 3 o'clock position (zero degrees). If the stop angle is not specified, then a circle is drawn, starting and stopping at the specified start angle. If no parameters are specified, then a circle is drawn with a radius equal to the radius, (in plotter units) of the last arc or circle, whether clockwise or counterclockwise. This radius variable is reset to zero at power-on and during an initialize operation so that it must be explicitly specified after these operations. Arcs are subject to the current arc tolerance, grid size, graphic limits, rotation and dash mode. The chords which approximate a circle may be slightly different in the clockwise and counterclockwise directions, owing to numerical roundoff and grid anomalies. Normally a minimum of eight chords are generated for a circle, but their end points fall on the nearest grid points. With extremely course grids, this may result in fewer than eight chords for circles with very small radii.

Fixed Dash Line

~ Q [{<SBN>} <MBN>]

Variable Dash Line

~ R [{<SBN>} <MBN>]

{<SBN>}	Pattern definition, one to sixteen successive relative dash and space lengths, 0 to 31 (plus 32 for dashes)
<MBN>	Length of a single pattern in plotter units, 1 to 32767
	Default: Solid line restored

Description

These instructions establish a dash font which affects all subsequent drawing, except characters, until the dash mode is altered or terminated. Arbitrary patterns of up to sixteen spaces, dashes, and dots (i.e., zero-length dashes) can be specified. Spaces are specified by relative lengths of 0 to 31 (a zero-length space causes a momentary pen lift). Dashes are specified by relative lengths of 0 to 31, but with 32 added to differentiate spaces from dashes (e.g., a dash of length 2 is specified as 32 + 2 = 34). In FIXED dash lines, the pattern length is fixed, with the pattern repeating along successive vectors without regard to vertices. The pattern restarts at the beginning, following pen-up moves. In VARIABLE dash lines, the pattern length is adjusted for each vector such that an integral number of patterns fits along each vector, with a pattern length equal to or less than the specified nominal length. At least one complete pattern appears on each vector. Chords of internally-generated arcs are treated as individual vectors. Inaccuracies in variable dash lines develop when long vectors and/or short pattern lengths are specified due to numerical round offs. Fixed and variable dash lines are, of course, mutually exclusive. Only the most recent pattern is in effect at a given time.

Rotate

	w [<MBA>]
<MBA>	Incremental angle of rotation (counterclockwise) in degrees, 0 to 359.995 Default: Rotation is reset to zero degrees (i.e., no rotation)

Description

This instruction increases rotation by the specified incremental angle. All vectors, except absolute vectors specified in MOVE and DRAW instructions, are rotated by the current accumulated angle about their starting points. This has the effect of rotating whole figures or plots which are drawn with incremental vectors including internally generated arcs and characters.

Rotate At Last Angle

x

Description

Similar to the ROTATE instruction except that the angle of rotation is set to the angle between the three o'clock position and the most recent move by the plotter (excluding front panel positioning). Following power-on, initialize operations, and zero length moves, this angle is zero degrees.

Label Group Instructions

Label Mode On

~ ' [<STRING>] <TERM>	
<STRING>	A string of one or more ASCII characters; any ASCII characters allowed except NUL, ENQ, ESC, or DEL. Default: No operation
<TERM>	The currently-designated label termination character

General Description

This instruction establishes the Label Mode in the plotter. While Label Mode is in effect, all data processed from the plot data buffer is interpreted as a string of ASCII characters to be drawn or acted upon. Thus, all the ASCII characters of <STRING> and <TERM> are processed as a **label string**. Labeling begins at the current pen position. The Label Mode terminates after <TERM> has been processed.

The Label String

Any of the ASCII characters shown in Appendix D can be included in the label string except NUL, ENQ, ESC, or DEL, these four characters are not stored in the plot data buffer but are intercepted by the device control command processor. ASCII control codes (decimal values 0 – 32) are ignored, except for the format effectors and font selectors which are described in Table 10-6. Graphic characters are drawn to previously-specified size and slant, from the currently-selected character set (font). The drawn characters of each of the six available character sets, and their corresponding ASCII character codes, are shown in Appendix A. <TERM> is processed as a label string character before it causes the Label Mode to be terminated.

Table 10-6. Format Effectors and Font Selectors

OCTAL CODE	DECIMAL CODE	ASCII NAME	EFFECT WHEN PROCESSED IN A LABEL STRING
003	03	ETX	Default Label Terminator. No operation if another character is the currently-designated label terminator.
010	08	BS	Backspace. The character origin is moved back one character-space.
011	09	HT	Half-space. The character origin is advanced one-half character-space.
012	10	LF	Line Feed. The character origin and label origin are lowered one line-space.
013	11	VT	Inverse Line Feed. The character origin and label origin are raised one line-space.
014	12	FF	Set Label Origin. The label origin is reset to the current character origin.
015	13	CR	Carriage Return. Current character origin is moved to the location of the label origin.
016	14	SO	Select Alternate Character Set. Subsequent graphic characters are drawn using the currently-designated alternate font.
017	15	SI	Select Standard Character Set. Subsequent graphic characters are drawn using the currently-designated standard font.
040	32	SPACE	Space. Current character origin is advanced one character-space.
NUL ENQ ESC DEL Always excluded from label strings. All other control codes not shown are normally ignored (no operation).			

Label Placement and Orientation

Each character in a label occupies an area of logical plotting space whose dimensions are referenced to a point called the **character origin** (refer to Figure 10-5). The initial label character origin is established at the current logical pen position following any of these operations: front panel positioning; MOVE, DRAW, INCREMENTAL MOVE, INCREMENTAL DRAW, or ARC CLOCKWISE or COUNTERCLOCKWISE instructions; or Power On and Initialize operations.

Since graphic characters and format effectors are incrementally generated, character orientation and labeling direction are subject to rotation produced by programmed instruction or by the front panel controls. (The latter method is effective only in LOCAL mode.)

Label Origin

The **label origin** is the point to which the pen moves in response to a carriage return (CR). It is reset to the current logical pen position following any of these operations: front panel pen positioning; MOVE or DRAW instructions; or processing of a (FF) control character while in Label Mode. It is reset to the Lower Left limit position following Power On and Initialize operations. The label origin is not affected by INCREMENTAL MOVE, INCREMENTAL DRAW, ARC CLOCKWISE or COUNTERCLOCKWISE instructions, nor by termination of a previous Label Mode. Line-feed control characters (LF) and (VT) cause the label origin to be moved up or down one line-space, perpendicular to the direction of labeling (refer to Table 10-6).

Centered Symbols

The centered symbols are those symbols of character set No. 5 whose decimal equivalent values are 65-79 (refer to Appendix A). Each of these fifteen symbols is drawn with its geometric center located at the current character origin. Unlike all other graphic characters and symbols, the current character origin is not automatically advanced one character-space upon completion of the symbols.

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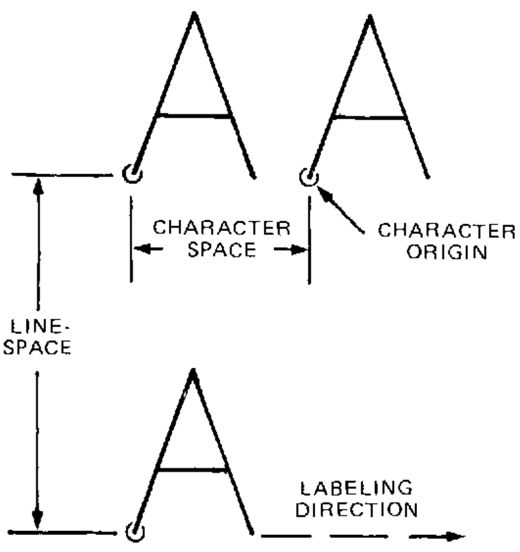


Figure 10-5. The Character Origin

Clipping

Labels are subject to clipping at the graph limits. The current character origin and current label origin are logical positions maintained by plotter firmware, and may lie outside the graph limits. Drawn characters are clipped on a vector-by-vector basis. The end points of character vectors, like all vectors, fall on grid points; with very coarse grids this may cause characters to appear distorted.

Defaults and Termination

If <STRING> is omitted from the LABEL MODE ON instruction, the Label Mode is invoked but no graphic operations occur, except for whatever graphic results the label termination character <TERM> produces.

Defaults and Termination (Continued)

Once invoked, Label Mode can be terminated only by <TERM>, by a Power-Off/Power On sequence, by an Initialize operation generated from the front panel, or by receipt of an ABORT GRAPHIC INSTRUCTION sequence ESC . K . Other graphic instructions cannot be executed while Label Mode is in effect; an attempt to do so merely causes the plotter to draw the characters which are comprised of the instructions. (This is the effect of inadvertent omission of the label termination character.)

Error Marker

If a parity error, transmission "framing" error or buffer overflow error is detected while a label string is being received by the plotter, an error marker is inserted at that point into the plot data buffer. When the label string is processed, each error marker causes an error symbol, consisting of five vertical lines to be drawn.

Set String Terminator

~ \ [<MBN>]	
<MBN>	Numeric equivalent of the label string terminator character; any value 1 – 126 except 5 or 27. Default: 3 (ETX character).

Description

This instruction designates the ASCII character required to terminate the label mode; i.e., it specifies the required <TERM> character for subsequent LABEL MODE ON instructions. Any character can be specified except NUL, ENQ, ESC, and DEL, since these four characters are not stored in the plot data buffer but are intercepted by the device control processor.

Defaults

If a SET STRING TERMINATOR instruction is processed in which the parameter is omitted, a value of 3 is assumed (ETX character).

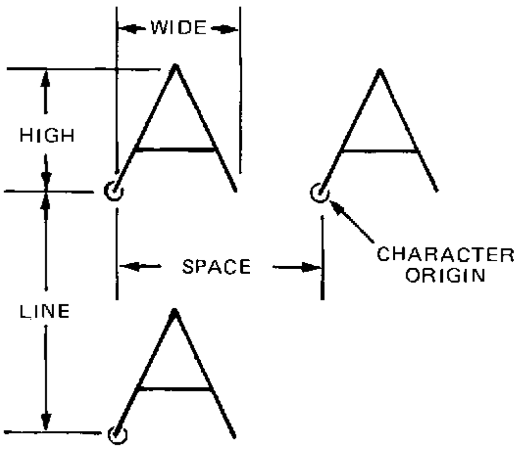
Initialize operations automatically establish the default string terminator, ETX.

Label Size

~ % [<MBP>]	
<MBP>	Character Spacing, Line Spacing in plotter units, each 0 to 16383 Default: 25, 50

Description

This instruction specifies the character size and spacing dimensions of label characters produced by subsequent label mode operations. The parameter actually specifies only the spacing dimensions (called "SPACE, LINE" in Figure 10-6), but the size of the drawn characters is thereby implied. For example, for full upper-case alphabetic characters such as "A", character width is two-thirds of the SPACE dimension and height is one-half the LINE dimension (refer to Figure 10-6).



$\frac{\text{LINE}}{\text{HIGH}} = 2 \qquad \frac{\text{SPACE}}{\text{WIDE}} = \frac{3}{2}$

Figure 10-6 Character Line and Space Definitions

Altering Only One Dimension

If either of the component values of the <MBP> parameter is specified as zero, the corresponding dimension remains unchanged. The other dimension is changed to the specified non-zero value.

Defaults

If a LABEL SIZE instruction is processed in which the parameters are omitted, the default values 25, 50 are assumed.

Initialize operations automatically establish default dimensions (SPACE 25, LINE = 50). With default grid size and graph limits, this yields 8 characters per inch horizontally and 4 lines per inch vertically.

Extreme Values

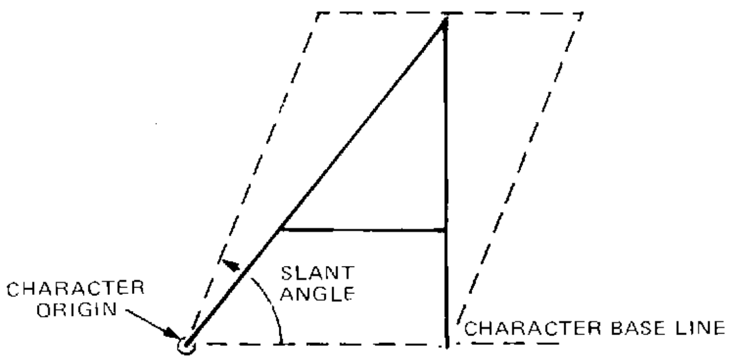
Although the LABEL SIZE instruction processes any spacing parameter which has a valid MBP format without generating errors, some component values which are extreme (too large or too small) may produce unreasonable results, such as partial characters, or degenerate or distorted characters. The latter two cases are more likely to occur with small spacing values and coarse gridding.

Label Slant

(~) (/) [<MBA>]
<MBA> Angle of character slant, in degrees counterclockwise from the character base, from 0 to 359.995, but treated as modulo 180 Default: 90 degrees (vertical, rectangular characters)

Description

This instruction specifies the slant angle of label characters produced by subsequent label mode operations. The slant angle is defined as the angle formed by the character base-line and the side of an imaginary parallelogram enclosing the character space (refer to Figure 10-7). "Label slant" refers to the slant of individual characters, not to the angle of rotation of the line of lettering. The slant angle, being relative to the base line of lettering, is not altered if the line of lettering is rotated by means of a ROTATE or ROTATE AT LAST ANGLE instruction. The slant angle does not influence the effect of format control characters processed in a label string. Specifically, the line-feed (LF) and inverse line-feed (VT) characters produce displacement in a direction perpendicular to the character base-line, regardless of the slant angle.



Angles Greater Than 180 Degrees

Because the slant angle is not intended to change character orientation, the specified angle is treated as a modulo 180 number. Angles specified greater than 180 degrees produce characters drawn at slant angles of 180 degrees less than the specified value, rather than characters which are upside-down.

Defaults

If the slant angle parameter is omitted from a LABEL SLANT instruction, the default value of 90 degrees is assumed. Initialize operations automatically establish the default slant angle of 90 degrees.

Extreme Values

The LABEL SLANT instruction processes any valid <MBA> parameter without generating errors. However, values approaching 0, 180, or 359 degrees can produce undesirable displacement of the tops of characters, or moves of illegal magnitudes. (Such moves are ignored, generation of the current character is aborted, and the plotter continues to the next character.)

Label Font

~ P [<MBP>]
<MBP> Standard, Alternate character sets (fonts), each 0 to 5 Default: Standard, Alternate = 0, 0

Description

This instruction designates which of the available fonts are to be considered the Standard and Alternate character sets for processing of ASCII characters in subsequent Label Mode operations. The available fonts and their assigned font numbers are shown in Appendix A.

Font Selection

The LABEL FONT instruction does not invoke **selection** of a font for label processing. Selection between the currently-designated Standard font and the currently-designated Alternate font is accomplished by default (refer to "Defaults" paragraph below), or by the function of two control characters which may be processed while in Label Mode:

SO invokes the currently-designated Alternate font;

SI invokes the currently-designated Standard font

Defaults

If the parameter is omitted in a LABEL FONT instruction, values of 0, 0 are assumed.

Initialize operations automatically designate Font No. 0 as both the Standard and Alternate fonts, and invoke selection of the Standard font for label processing.

Out-of-Range Error

If the LABEL FONT instruction specifies a font which is not available (i.e., either of the component values of <MBP> are greater than 5), the corresponding font designation remains unchanged, and an "out-of-range" error is generated in the plotter.

Macro Instruction Group

Macro Instruction Define

~ * [<SBN> [<PDS>]] z	
<SBN>	Assigned macro number
<PDS>	Graphic data string to be stored in RAM
	Default: ~ * <SBN> z Erases macro stored under assigned macro number
z	Macro terminate
	Default: ~ * z Erases all stored macros

Description

The graphic data and instructions to be stored in user RAM under the assigned macro number are defined between the assigned number and the macro terminate byte. Within the macro, the Label Mode, if invoked, must be terminated before the macro terminate z is sent.

A macro can be used to invoke, but not to define other macros also, it cannot be used to invoke itself either directly or indirectly through other macros. When a macro is accessed but no new graphic data string is sent, the macro previously stored under that macro number is erased.

When a macro define instruction is sent without a macro number and graphic data string then, all macros stored in RAM are erased.

As macros are erased, the memory space that they had occupied becomes available again for input buffer data. Similarly, as macros are defined, the available data buffer space is reduced.

It is better to define macros which consist of whole graphic instructions although, it is not mandatory.

Macro Instruction Invoke

{	<SBN>
<SBN>	Assigned macro instruction number

Description

Initiates the execution of a previously defined macro. RAM is searched first for the designated macro. If it is not found there, the optional plug-in ROM is searched. If no such macro is found an error indication will result.

NOTE

Macro number 0 is automatically searched for during the plotter power-up sequence and, if found in the plug-in ROM, it is invoked.

Automatic Macro Instruction

~ # [<SBN>]		
<SBN>	Macro instruction number (0 – 63)	
	Default: ~ #	Automatic mode is terminated

Description

This instruction causes the specified macro to be automatically invoked upon completion of each arc and vector plot.

Automatic macro cannot be invoked within an automatically invoked macro, not even to terminate the automatic macro mode.

If the specified macro does not exist in memory, the Error lamp will light. Refer to Output Error Instruction.

To terminate the automatic macro mode, send the Automatic Macro instruction without specifying a Macro number (~ #).

Paper Advance Group Instructions

General

These instructions pertain only to the 7221S Plotter which has automatic paper advance.

The paper advance option is "on" if the "out-of-paper" sensor (microswitch) indicates roll paper is loaded, otherwise the paper advance option is "off".

NOTE

If these instructions are sent to a 7221B, all instructions are processed as if the paper advance option were "off".

Cutter Enable

~ (	
DEFAULT:	At plotter power-on, cutter is enabled.

Description

This instruction turns the cutter on and illuminates the CUTTER ENABLE lamp. If the cutter is already on, this instruction is ignored. The state of the cutter is independent of the state of the paper advance option, but has no effect if the paper advance option is off. If the cutter is on, the paper is cut when it is advanced either a full page or a half page. The location of the cut is along the line which coincides with the left edge of the platen at the time of the paper advance command.

Cutter Disable

~	)

Description

This instruction turns the cutter off and extinguishes the CUTTER ENABLE lamp. If the cutter is already off, this instruction is ignored.

Advance Full Page

~	+

Description

This instruction causes roll paper to be advanced one full page. If the cutter is on, the paper is cut along the line which coincides with the left edge of the platen at the time of the advance full page instruction. When the advance option is off (out-of-paper), execution of this instruction causes error 4 to be set. Error 4 is also set if the out-of-paper sensor indicates no paper after completion of an advance.

Advance Half Page

~	-

Description

This instruction is identical to the ADVANCE FULL PAGE instruction except that roll paper is advanced a half page.

Implementing the Paper Advance Group

The flowchart shown in Figure 10-8 suggests one method of implementing the paper advance group instructions in combination with the OUTPUT EXTENDED STATUS instruction in a graphic program.

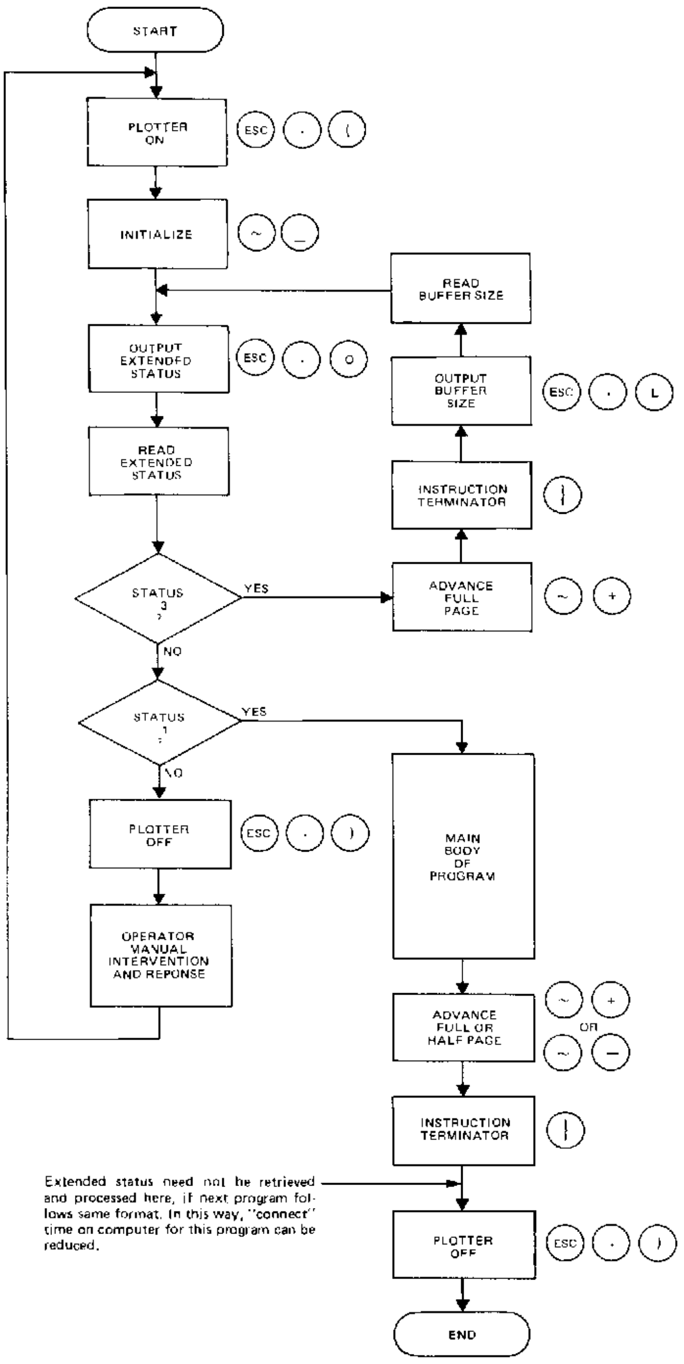


Figure 10-8. Implementing the Paper Advance Group

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Chapter 11
Interfacing The Plotter

Introduction

This chapter contains the following discussion:

- General Information
- Data Connectors
- Interface Wiring Designations
- Electrical Signal Characteristics
- Control Line Protocol
- Transmission Errors
- Stop Bits
- Output Baud Rate

General Information

The 7221B and 7221S Plotters are designed for use in either remote interfaced computer systems via a modem or with hardwire connections to the host computer. The Plotter is connected in series between the computer and the terminal as shown in Figure 11-1.

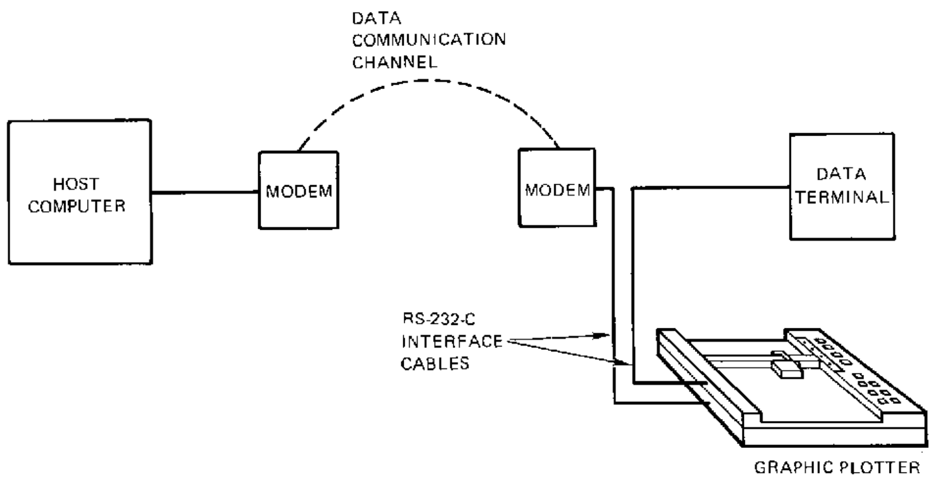


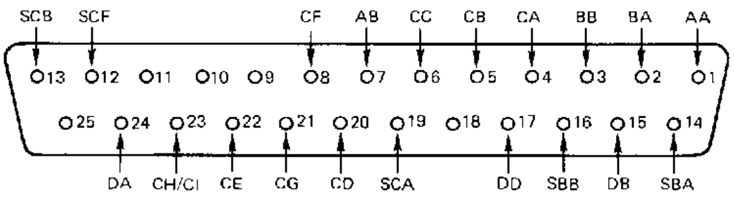
Figure 11-1. Typical Plotter Installation

Data is exchanged between the equipment as defined in the Electronic Industries Association (EIA) Standard RS-232-C and the International Telegraph and Telephone Consultive Committee (CCITT) Recommendation V.24.

The above Standards apply to the interconnection of data terminal equipment (DTE) and data communication equipment (DCE) using serial binary data interchange.

Data Connectors

The Plotter rear panel contains two female RS-232-C/CCITT V.24 connectors. (Refer to Figure 2-1.) The upper connector is used to interface the Plotter with a terminal, and the lower connector is used to interface with a modem. A male-to-male interface cable (HP Part No. 07221-60157) is provided as a standard accessory for interconnection purposes. The pin arrangement and wiring color code for the above cable and connectors is shown in Figure 11-2. Note that all wires are wired straight through between the cable connectors.



COLOR CODE					
PIN	COLOR	PIN	COLOR	PIN	COLOR
1	BRN	10	WHT-BLK	19	WHT-BLK-BRN
2	RED	11	WHT-BRN	20	WHT-BLK-RED
3	ORN	12	WHT-RED	21	WHT-BLK-ORN
4	YEL	13	WHT-ORN	22	WHT-BLK-YEL
5	GRN	14	WHT-YEL	23	WHT-BLK-GRN
6	BLU	15	WHT-GRN	24	WHT-BLK-BLU
7	VIO	16	WHT-BLU	25	BLK
8	GRA	17	WHT-VIO		
9	WHT	18	WHT-GRA		

Figure 11-2. Interface Connector and Wiring Color Code

Interface Wiring Designations

The EIA RS-232-C Standard defines the 25 wires and their respective signal functions that are used to interface the Plotter with the Data Terminal/Host Computer. Note that only seven basic wires are connected to the Plotter's internal circuitry. The remaining wires bypass the Plotter by being hardwired between the MODEM port (connector) and the TERMINAL port on the rear panel of the Plotter. These seven basic wires and their respective signal designations are shown in Table 11-1.

Table 11-1. EIA RS-232-C and CCITT V.24 Interface Data and Control Lines

Wire/Signal Name	Circuit		Function	
	RS-232-C	CCITT	Modem	Terminal
Transmitted Data	BA	103	Outgoing data from the plotter.	Incoming data to the plotter from the terminal.
Received Data	BB	104	Incoming data to the plotter.	Outgoing data from the plotter to the terminal.
Request to Send	CA	105	Plotter activated, tells the modem to prepare to receive and retransmit data from the plotter.	Terminal activated, tells the plotter to prepare to receive data from the terminal.
Clear to Send (Ready for Sending)	CB	106	Activated by the modem to tell the plotter that it is ready to receive and retransmit data from the plotter.	Activated by the plotter to tell the terminal that the plotter is ready to receive.
Data Set Ready	CC	107	Activated by the modem to tell the plotter that the modem is operational.	Activated by the plotter to tell the terminal that the plotter is operational.
Data Terminal Ready	CD	108.2	Plotter activated to tell the modem that the plotter is operational.	Activated by the terminal to tell the plotter that the terminal is operational.
Received Line (Data Channel Received Line Signal Detector)	CF	109	Activated by the modem to tell the plotter that the modem is in communication with the host computer and detects the carrier signal.	Tied high (to simulate a modem) for terminals that require this line to be high.

Electrical Signal Characteristics

The signal operating levels employed in an EIA RS-232-C Standard communication channel are shown in Table 11-2.

Table 11-2. Data Communication Signal Logic Levels

VOLTAGE	>+3V but <+25V	<-3V but >-25V
DATA LINES:		
Name	Space	Mark
Logic	0 (OFF)	1 (ON)
CONTROL LINES:	ON (true)	OFF (false)

Figure 11-3 shows the simplified equivalent circuits of the Plotter's input and output.

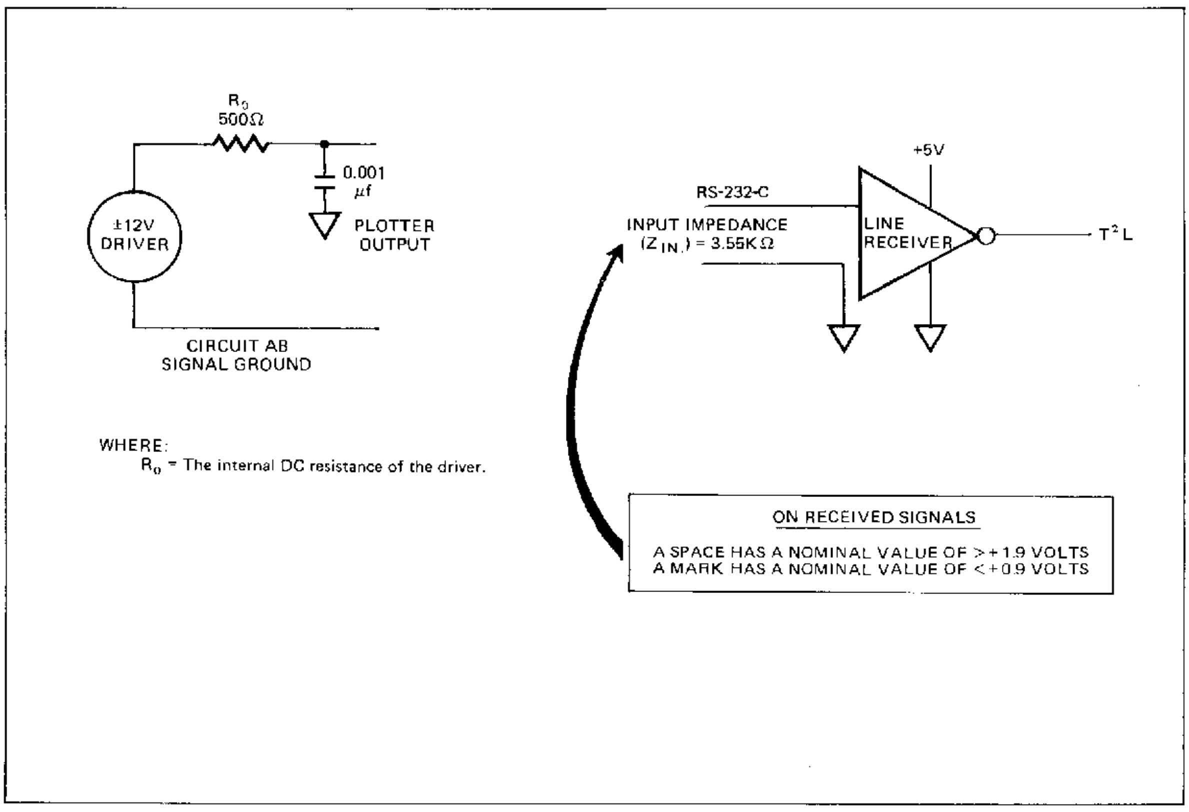


Figure 11-3. Plotter Driver and Terminator Equivalent Circuits

Control Line Protocol

It should be noted that in the ON LINE PROGRAMMED ON MODE, all data generated by the Plotter is routed to the modem. Data generated by the terminal is routed through to the modem on a non-interference basis so that data being transmitted by the Plotter will not be interrupted by terminal data. However, all data generated by the Host computer (and passed through the modem) is intercepted by the Plotter and is not passed on to the terminal.

NOTE

The above data routing is true unless "Monitor Mode" is active. Refer to Chapter 10 for a definition of "Monitor Mode."

Figure 11-4 is a flow chart representation of the subroutine protocol the Plotter observes for Line, Local and Standby modes of operation. Table 11-3 shows the state of the various lines during the above modes of operation.

Table 11-3. Plotter Modes and Line States

Plotter Mode	Data Set (Modem) Port Signal Lines		Terminal Port Signal Lines	
	Receive Lines	Driven Lines	Receive Lines	Driven Lines
Standby				Sets Data Terminal Ready (CD) High (ON) to modem.
Local	Not monitored	Sets to Low (OFF) Data Terminal Ready (CD) Request to Send (CA) Transmitted Data (BA)	Request to Send (CA) is monitored.	Sets to High (ON) State: Data Set Ready (CC) Clear to Send (CB) if Request to Send (CA) is High. Received Line Signal Detector (CF).
Line	Data Set Ready (CC) turns front panel data lamp on. Clear to Send (CB) is monitored if Data Set Ready (CC) is High (ON). Received Data (BB) is routed to plotter if plotter is programmed "ON" and through plotter to terminal if "OFF".	Data Terminal Ready (CD) is set High (ON). Request to Send (CA) is set High if Data Set Ready (CC) is High (ON). Transmitted Data (BA) is allowed to be set High if Data Set Ready (CC) and Clear to Send (CB) are High (ON).	Request to Send (CA) is monitored. If a Break Signal is received on transmitted data (BA) plotter generates a 200 millisecond break on modem Transmitted Data (BA) line. Data received is sent to host computer if no output from plotter is pending or in progress.	Sets to High State (ON): Data Set Ready (CC) Clear to Send (CB) if Request to Send (CA) is High (ON). Received Line Signal Detector (CF).

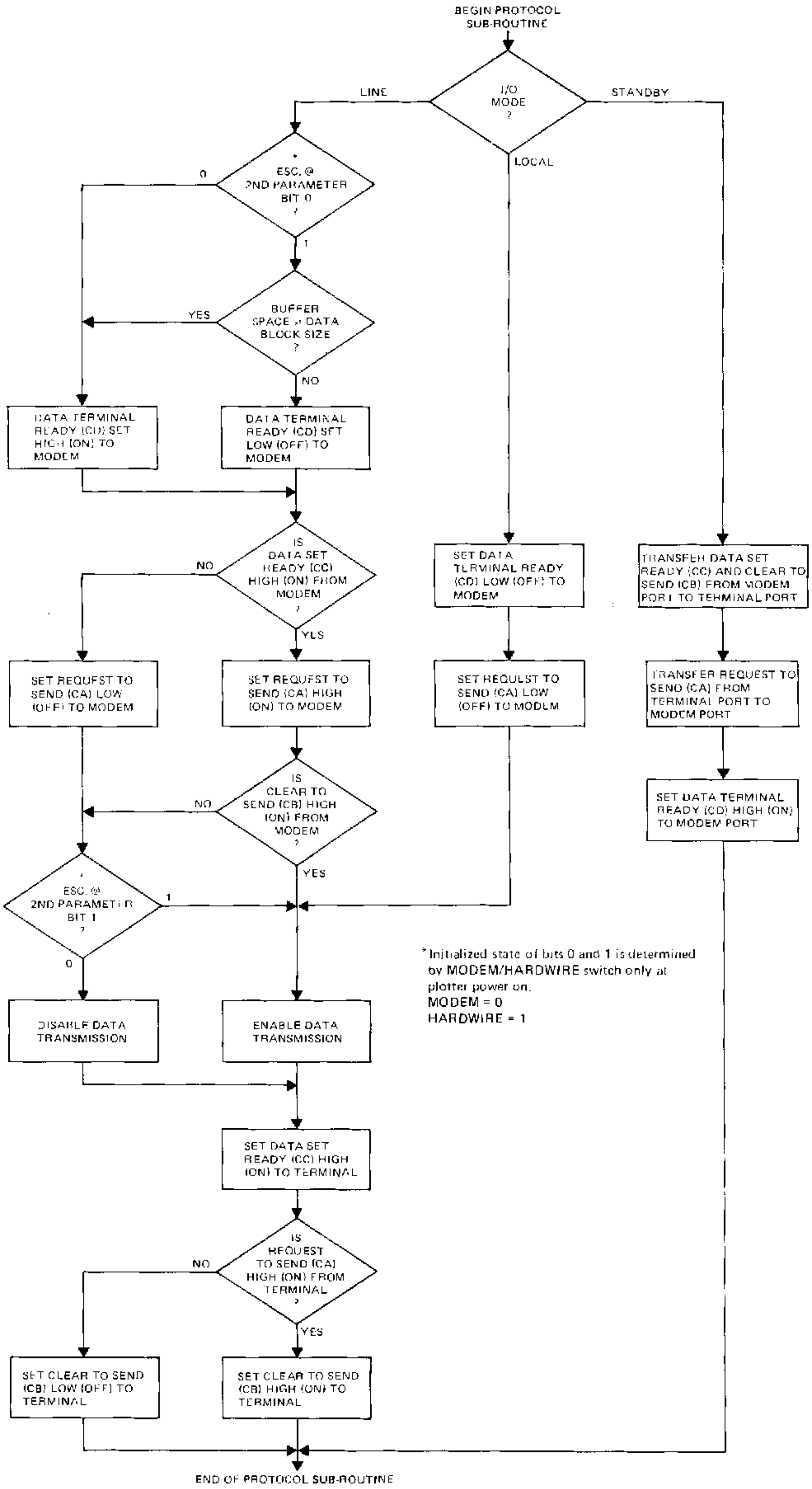


Figure 11-4. Plotter Modes Control Line Protocol

Transmission Errors

Depending upon its operating mode, the plotter upon receiving either a framing error or a parity error responds as follows:

RECEIVED FROM MODEM

With the plotter programmed "ON", status bit 14 (refer to Appendix C) is set, the defective byte is dropped from the buffer and is replaced by the DEL (127_{10}) ASCII character. The ERROR ● lamp is turned on steady when the delete character is encountered in the buffer. The plotter, when interrogated will indicate an output error 20. (Refer to Appendix C.)

With the plotter either programmed "OFF" or, in the STANDBY mode, the defective byte is dropped from the buffer and replaced by the DEL ASCII character.

RECEIVED FROM TERMINAL

The response of the plotter upon receipt of a framing error is the same as its response to a BREAK signal. As stated in Chapter 3, the BREAK signal aborts output instructions while leaving macroinstructions intact. Also, the plotter is turned programmatically "OFF".

A buffer overflow error occurs when more bytes are received by the plotter than the available buffer space. Note that the overflowing data is lost, thereby causing status bit 12 to be set. In this event, an error marker character overlays the last byte received by the buffer which, when decoded, causes error 20 to be set and increments the error counter. Typically, this occurs when the handshake mode has not been set.

Stop Bits

The plotter automatically verifies/generates two stop bits at the 75 and 110 baud rates and one stop bit at baud rates greater than 110.

NOTE

Two stop bits can be selected at all baud rates by removing jumper wire W1 on Serial I/O PCA 07221-60153 (A2).

Output Baud Rate

When the plotter responds to an output instruction, its transmission will be at the baud rate set by the rear panel BAUD RATE switch.

Appendix A

Label Mode Character Sets (Fonts)

Format Affectors

The following list of ASCII characters are used as format affectors when the plotter is in the label mode. For a complete list of ASCII characters and their plotter functions refer to Appendix D.

ASCII CHARACTER	264X KEYBOARD	DECIMAL CODE	FUNCTION
BS	CNTL H	8	Backspace
HT	CNTL I	9	Half-space forward
LF	CNTL J	10	Line feed
VT	CNTL K	11	Inverse line feed
FF	CNTL L	12	Set label origin
CR	CNTL M	13	Carriage return
SO	CNTL N	14	Select Alternate Character Set
SI	CNTL O	15	Select Standard Character Set

Character Sets

DECIMAL CODE	SET Ø ANSI ASCII	SET 1 9872 ASCII	SET 2 EUROPEAN	SET 3 SCANDINAVIAN	SET 4 SPANISH/ LATIN AMERICAN	SET 5 GRAPHIC SYMBOLS
33	!	!	!	!	!	!
34	"	"	"	"	"	"
35	#	#	£	£	¿	#
36	$	$	$	$	$	$
37	%	%	%	%	%	%
38	&	&	&	&	&	&
39	'	'	´	'	´	'
4Ø	(	(	(	(	(	(
41	)	)	)	)	)	)
42	*	*	*	*	*	*
43	+	+	+	+	+	+
44	,	,	,	,	,	,
45	-	-	-	-	-	-
46	.	.	.	.	.	.
47	/	/	/	/	/	/
48	Ø	Ø	Ø	Ø	Ø	Ø
49	1	1	1	1	1	1
5Ø	2	2	2	2	2	2
51	3	3	3	3	3	3
52	4	4	4	4	4	4
53	5	5	5	5	5	5
54	6	6	6	6	6	6
55	7	7	7	7	7	7
56	8	8	8	8	8	8
57	9	9	9	9	9	9
58	:	:	:	:	:	:
59	;	;	;	;	;	;
6Ø	<	<	<	<	<	<
61	=	=	=	=	=	=
62	>	>	>	>	>	>
63	?	?	?	?	?	?

Character Sets (Continued)

DECIMAL CODE	SET Ø ANSI ASCII	SET 1 9872 ASCII	SET 2 EUROPEAN	SET 3 SCANDINAVIAN	SET 4 SPANISH/ LATIN AMERICAN	SET 5 GRAPHIC SYMBOLS
64	@	@	@	@	@	@
65	A	A	A	A	A	⊡
66	B	B	B	B	B	⦶
67	C	C	C	C	C	△
68	D	D	D	D	D	+
69	E	E	E	E	E	×
7Ø	F	F	F	F	F	◇
71	G	G	G	G	G	↑
72	H	H	H	H	H	⧖
73	I	I	I	I	I	Z
74	J	J	J	J	J	Y
75	K	K	K	K	K	⌧
76	L	L	L	L	L	✳
77	M	M	M	M	M	⧖
78	N	N	N	N	N	|
79	O	O	O	O	O	✡
8Ø	P	P	P	P	P	-
81	Q	Q	Q	Q	Q	'
82	R	R	R	R	R	R
83	S	S	S	S	S	S
84	T	T	T	T	T	T
85	U	U	U	U	U	U
86	V	V	V	V	V	V
87	W	W	W	W	W	W
88	X	X	X	X	X	X
89	Y	Y	Y	Y	Y	Y
9Ø	Z	Z	Z	Z	Z	Z
91	[	[	[	Ø	[	[
92	\	√	ç	Æ	¡	\
93	]	]	]	ø	]	]
94	^	↑	^	æ	^	^
95	_	_	_	_	_	_

Character Sets (Continued)

DECIMAL CODE	SET Ø ANSI ASCII	SET 1 9872 ASCII	SET 2 EUROPEAN	SET 3 SCANDINAVIAN	SET 4 SPANISH/ LATIN AMERICAN	SET 5 GRAPHIC SYMBOLS
96	`	`	`	`	`	`
97	a	a	a	a	a	∩
98	b	b	b	b	b	⊃
99	c	c	c	c	c	⊂
1ØØ	d	d	d	d	d	∪
1Ø1	e	e	e	e	e	—
1Ø2	f	f	f	f	f	≡
1Ø3	g	g	g	g	g	≅
1Ø4	h	h	h	h	h	≈
1Ø5	i	i	i	i	i	~
1Ø6	j	j	j	j	j	≤
1Ø7	k	k	k	k	k	≥
1Ø8	l	l	l	l	l	≠
1Ø9	m	m	m	m	m	Δ
11Ø	n	n	n	n	n	Π
111	o	o	o	o	o	Σ
112	p	p	p	p	p	±
113	q	q	q	q	q	∓
114	r	r	r	r	r	→
115	s	s	s	s	s	↑
116	t	t	t	t	t	←
117	u	u	u	u	u	↓
118	v	v	v	v	v	v
119	w	w	w	w	w	w
12Ø	x	x	x	x	x	x
121	y	y	y	y	y	y
122	z	z	z	z	z	z
123	{	π	¨	¨	~	{
124	¦	⊢	°	°	~	¦
125	}	→	¨	¨	~	}
126	~	~	[illegible]	°	~	~

Appendix B

Binary Coding Table

Instruction	Range		Bits: 7	6	5	4	3	2	1
Device Control Instructions		ESC	0	0	1	1	0	1	1
		•	0	1	0	1	1	1	0
			*C	C	C	C	C	C	C
Graphic Instructions									
First Order			1	1	1	C	C	C	C
Second Order		~	1	1	1	1	1	1	0
			*C	C	C	C	C	C	C
Numerical Parameters									
SBN—Single Byte Number Range: Ø to 63 Structure: 1 byte			*C	N	N	N	N	N	N
MBN—Multiple Byte Number Range: Ø to 32767 Structure: 1 to 3 bytes	Ø to 15		1	1	0	N	N	N	N
	Ø to 1Ø23		1	1	0	N	N	N	N
			*C	N	N	N	N	N	N
	Ø to 32767		1	1	0	0	N	N	N
			*C	N	N	N	N	N	N
			*C	N	N	N	N	N	N
MBP—Multiple Byte Pair of Numbers Range: Ø to 16383 for each number Structure: 1 to 5 bytes total	Ø to 3		1	1	0	X	X	Y	Y
	Ø to 31		1	1	0	X	X	X	X
			*C	X	Y	Y	Y	Y	Y
	Ø to 255		1	1	0	X	X	X	X
			*C	X	X	X	X	Y	Y
			*C	Y	Y	Y	Y	Y	Y
	Ø to 2Ø47		1	1	0	X	X	X	X
			*C	X	X	X	X	X	X
			*C	X	Y	Y	Y	Y	Y
			*C	Y	Y	Y	Y	Y	Y
	Ø to 16383		1	1	0	X	X	X	X
			*C	X	X	X	X	X	X
			*C	X	X	X	X	Y	Y
			*C	Y	Y	Y	Y	Y	Y
			*C	Y	Y	Y	Y	Y	Y
PMB—Pair of Multiple Byte Numbers Range: -16384 to 16383 for each number Structure: 1 to 3 bytes for each number 2 to 6 bytes total	-16 to 15		1	0	X	X	X	X	X
			0	1	Y	Y	Y	Y	Y
	-512 to 511		1	0	X	X	X	X	X
			1	0	X	X	X	X	X
			0	1	Y	Y	Y	Y	Y
			0	1	Y	Y	Y	Y	Y
	-16384 to 16383		1	0	X	X	X	X	X
			1	0	X	X	X	X	X
			1	0	X	X	X	X	X
			0	1	Y	Y	Y	Y	Y
			0	1	Y	Y	Y	Y	Y
			0	1	Y	Y	Y	Y	Y
MBA—Multiple Byte Angle Resolution: 1 byte = 22.5° 2 bytes = 0.352° 3 bytes = 0.005° Structure: 1 to 3 bytes	180° to 22.5°		1	1	0	A	A	A	A
	11.25° to 0.352°		*C	A	A	A	A	A	A
	0.176° to 0.005°		*C	A	A	A	A	A	A

First Byte	Second Byte	Third Byte
Bit 3 = 180°	Bit 5 = 11.25°	Bit 5 = 0.176°
Bit 2 = 90°	Bit 4 = 5.63°	Bit 4 = 0.088°
Bit 1 = 45°	Bit 3 = 2.81°	Bit 3 = 0.044°
Bit 0 = 22.5°	Bit 2 = 1.41°	Bit 2 = 0.022°
	Bit 1 = 0.703°	Bit 1 = 0.011°
	Bit 0 = 0.352°	Bit 0 = 0.005°

*Identifies control bit 6 that is the complement of bit 5.

Appendix C
Plotter Status And Error Codes

Output Error Types

To Acquire Use ESC . E

ERROR TYPE	DESCRIPTION
0	No errors.
1	Invalid byte received when graphic instruction expected.
2	Invalid byte received following a ~ in a graphic instruction.
3	Invalid byte received following the ESC . in a device control instruction.
4	Out of paper or paper advance option is "off" when either ~ + or ~ - instruction is received.
5	Missing parameter in an INCREMENTAL MOVE or DRAW, or DASH LINES instruction.
6	Parameter out-of-range.
7	Too many bytes in a multi-byte parameter.
8	Too many space/dash parameters in a DASH LINES instruction or too many <ASC> parameters in a SET OUTPUT MODE or SET HANDSHAKE MODE instruction.
9	Not Used.
10	Output instruction received while another output instruction is executing.
11	A LABEL instruction contains a character with an oversize vector.
12	Not Used.
13	An AUTOMATIC MACRO instruction has been encountered in an automatically invoked macro.
14	An AUTOMATIC MACRO instruction has specified a non-existent macro.
15	A MACRO INVOKE instruction has specified a non-existent macro.
16	A MACRO INVOKE instruction has attempted an invoke of itself .
17	A MACRO DEFINE instruction has been attempted within a MACRO DEFINE instruction
18	A MACRO DEFINE instruction defines a macro which is bigger than the available space.
19	A transmission error has occurred in a MACRO DEFINE instruction.
20	A transmission error has been detected in a graphic instruction.
99	An internal error has been detected. ERROR lamp is flashing.

Output Status Word

To Acquire Use ESC . F

BIT	DECIMAL EQUIVALENT	DESCRIPTION
		– PEN CONDITIONS –
0	1	Pen Up/Down (0/1)
1	2	
2	4	
3	8	
		0 0 0 No PEN SELECT instruction since power on; no pen in holder.
		0 0 1 Pen 1 most recently selected.
		0 1 0 Pen 2 most recently selected.
		0 1 1 Pen 3 most recently selected.
		1 0 0 Pen 4 most recently selected.
4	16	Pen stall 1 empty/occupied (0/1).
5	32	Pen stall 2 empty/occupied (0/1).
6	64	Pen stall 3 empty/occupied (0/1).
7	128	Pen stall 4 empty/occupied (0/1).
		– OPERATIONAL STATES – NO = 0 YES = 1
8	256	Front panel being serviced. Graphics suspended until done.
9	512	Pen position out of limits. OUT OF LIMITS light on steady.
10	1024	Macro instruction is being defined and stored.
		– ADVISORY CONDITIONS – NO = 0 YES = 1
11	2048	Plot variables have been altered by front-panel controls.
12	4096	Data buffer has overflowed or has been aborted.
		– ERROR CONDITIONS – NO = 0 YES = 1
13	8192	Input error detected. ERROR light is on steady.
14	16384	Transmission error has occurred.
15	-32768	Internal error has occurred. ERROR light is flashing.

Appendix D
ASCII Code Table

PLOTTER USAGE
SC • @ SET PLOTTER CONFIGURATION Instruction
SC • A OUTPUT IDENTIFICATION Instruction
SC • B OUTPUT BUFFER SPACE Instruction
SC • C OUTPUT CURRENT POSITION Instruction
SC • D OUTPUT DIGITIZED POINT Instruction
SC • E OUTPUT ERROR Instruction
SC • F OUTPUT STATUS Instruction
SC • G OUTPUT GRAPHIC LIMITS Instruction
SC • H SET HANDSHAKE MODE 1 Instruction
SC • I SET HANDSHAKE MODE 2 Instruction
SC • J ABORT DEVICE CONTROL Instructions
SC • K ABORT GRAPHIC Instructions
SC • L OUTPUT BUFFER SIZE Instruction
SC • M SET OUTPUT MODE Instruction
SC • N SET EXTENDED OUTPUT AND HANDSHAKE MODE Instruction
SC • O OUTPUT EXTENDED STATUS Instruction
P LABEL FONT Instruction
Q FIXED DASH LINES Instruction
R VARIABLE DASH LINES Instruction
S SET GRID SIZE Instruction
T ARC TOLERANCE Instruction
V VELOCITY SELECT Instruction
W SET GRAPH LIMITS Instruction
\ SET STRING TERMINATOR Instruction
_ INITIALIZE Instruction
First Byte of MBA, MBN, and MBP Parameters
MOVE Instruction
DRAW Instruction
INCREMENTAL MOVE Instruction
INCREMENTAL DRAW Instruction
ARC CLOCKWISE Instruction
ARC COUNTERCLOCKWISE Instruction
PEN SELECT Instruction
ROTATE Instruction
ROTATE AT LAST ANGE Instruction
No Operation
MACRO INSTRUCTION TERMINATE
MACRO INSTRUCTION INVOKE
No Operation
No Operation
First Character 2nd Order Graphic Instructions
Always Ignored

ASCII CHAR.	264X KEYBOARD	DECIMAL	OCTAL	BINARY BITS							
				7	6	5	4	3	2	1	0
@		64	100	0	1	0	0	0	0	0	0
A		65	101	0	1	0	0	0	0	0	1
B		66	102	0	1	0	0	0	0	1	0
C		67	103	0	1	0	0	0	0	1	1
D		68	104	0	1	0	0	0	1	0	0
E		69	105	0	1	0	0	0	1	0	1
F		70	106	0	1	0	0	0	1	1	0
G		71	107	0	1	0	0	0	1	1	1
H		72	110	0	1	0	0	1	0	0	0
I		73	111	0	1	0	0	1	0	0	1
J		74	112	0	1	0	0	1	0	1	0
K		75	113	0	1	0	0	1	0	1	1
L		76	114	0	1	0	0	1	1	0	0
M		77	115	0	1	0	0	1	1	0	1
N		78	116	0	1	0	0	1	1	1	0
O		79	117	0	1	0	0	1	1	1	1
P		80	120	0	1	0	1	0	0	0	0
Q		81	121	0	1	0	1	0	0	0	1
R		82	122	0	1	0	1	0	0	1	0
S		83	123	0	1	0	1	0	0	1	1
T		84	124	0	1	0	1	0	1	0	0
U		85	125	0	1	0	1	0	1	0	1
V		86	126	0	1	0	1	0	1	1	0
W		87	127	0	1	0	1	0	1	1	1
X		88	130	0	1	0	1	1	0	0	0
Y		89	131	0	1	0	1	1	0	0	1
Z		90	132	0	1	0	1	1	0	1	0
[		91	133	0	1	0	1	1	0	1	1
\		92	134	0	1	0	1	1	1	0	0
]		93	135	0	1	0	1	1	1	0	1
^		94	136	0	1	0	1	1	1	1	0
—		95	137	0	1	0	1	1	1	1	1
`		96	140	0	1	1	0	0	0	0	0
a		97	141	0	1	1	0	0	0	0	1
b		98	142	0	1	1	0	0	0	1	0
c		99	143	0	1	1	0	0	0	1	1
d		100	144	0	1	1	0	0	1	0	0
e		101	145	0	1	1	0	0	1	0	1
f		102	146	0	1	1	0	0	1	1	0
g		103	147	0	1	1	0	0	1	1	1
h		104	150	0	1	1	0	1	0	0	0
i		105	151	0	1	1	0	1	0	0	1
j		106	152	0	1	1	0	1	0	1	0
k		107	153	0	1	1	0	1	0	1	1
l		108	154	0	1	1	0	1	1	0	0
m		109	155	0	1	1	0	1	1	0	1
n		110	156	0	1	1	0	1	1	1	0
o		111	157	0	1	1	0	1	1	1	1
p		112	160	0	1	1	1	0	0	0	0
q		113	161	0	1	1	1	0	0	0	1
r		114	162	0	1	1	1	0	0	1	0
s		115	163	0	1	1	1	0	0	1	1
t		116	164	0	1	1	1	0	1	0	0
u		117	165	0	1	1	1	0	1	0	1
v		118	166	0	1	1	1	0	1	1	0
w		119	167	0	1	1	1	0	1	1	1
x		120	170	0	1	1	1	1	0	0	0
y		121	171	0	1	1	1	1	0	0	1
z		122	172	0	1	1	1	1	0	1	0
{		123	173	0	1	1	1	1	0	1	1
			124	174	0	1	1	1	1	1	0	0
}		125	175	0	1	1	1	1	1	0	1
~		126	176	0	1	1	1	1	1	1	0
DEL		127	177	0	1	1	1	1	1	1	1

0	PLOTTER USAGE
0	Null (always ignored)
1	
0	Turns Label Mode On (LOCAL Mode only)
1	Default Label Terminator
0	
1	Causes Automatic ACK
0	Automatic Response to ENQ
1	
0	Backspace
1	Half-space Forward
0	Line Feed (Typical Echo Bypass)
1	Inverse Line Feed
0	Set Label Origin
1	Carriage Return (Default Output Terminator)
0	Select Alternate Character Set
1	Select Standard Character Set
0	
1	Typical Output Trigger Character
0	
1	
0	
1	
0	
1	
0	
1	
0	
1	First Character of Device Control Instructions
0	
1	
0	
1	
0	
1	
0	
1	~ # AUTOMATIC MACRO Instruction
0	
1	~ % LABEL SIZE Instruction
0	
1	~ ' LABEL MODE ON Instruction
0	ESC • (PLOTTER ON Instruction / ~ (CUTTER ENABLE Instruction
1	ESC •) PLOTTER OFF Instruction / ~) CUTTER DISABLE Instruction
0	~ * MACRO DEFINE Instruction
1	~ + ADVANCE FULL PAGE Instruction
0	
1	~ - ADVANCE HALF PAGE Instruction
0	Second Character of Device Control Instructions
1	~ / LABEL SLANT Instruction
0	
1	
0	
1	
0	
1	Only allowed characters in the <ASC> parameter strings of the SET OUTPUT MODE and SET HANDSHAKE MODE 1 and 2 instructions
0	
1	
0	
1	
0	<ASC> String Terminator
1	<ASC> String Delimiter
0	
1	
0	
1	

ASCII CHAR.	264X KEYBOARD	DECIMAL	OCTAL	BINARY BITS 7	6	5	4	3	2	1
NULL	CNTL @	0	000	0	0	0	0	0	0	0
SOH	CNTL A	1	001	0	0	0	0	0	0	0
STX	CNTL B	2	002	0	0	0	0	0	0	1
ETX	CNTL C	3	003	0	0	0	0	0	0	1
EOT	CNTL D	4	004	0	0	0	0	0	1	0
ENQ	CNTL E	5	005	0	0	0	0	0	1	0
ACK	CNTL F	6	006	0	0	0	0	0	1	1
BEL	CNTL G	7	007	0	0	0	0	0	1	1
BS	CNTL H	8	010	0	0	0	0	1	0	0
HT	CNTL I	9	011	0	0	0	0	1	0	0
LF	CNTL J	10	012	0	0	0	0	1	0	1
VT	CNTL K	11	013	0	0	0	0	1	0	1
FF	CNTL L	12	014	0	0	0	0	1	1	0
CR	CNTL M	13	015	0	0	0	0	1	1	0
SO	CNTL N	14	016	0	0	0	0	1	1	1
SI	CNTL O	15	017	0	0	0	0	1	1	1
DLE	CNTL P	16	020	0	0	0	1	0	0	0
DC1	CNTL Q	17	021	0	0	0	1	0	0	0
DC2	CNTL R	18	022	0	0	0	1	0	0	1
DC3	CNTL S	19	023	0	0	0	1	0	0	1
DC4	CNTL T	20	024	0	0	0	1	0	1	0
NAK	CNTL U	21	025	0	0	0	1	0	1	0
SYN	CNTL V	22	026	0	0	0	1	0	1	1
ETB	CNTL W	23	027	0	0	0	1	0	1	1
CAN	CNTL X	24	030	0	0	0	1	1	0	0
EM	CNTL Y	25	031	0	0	0	1	1	0	0
SUB	CNTL Z	26	032	0	0	0	1	1	0	1
ESC	CNTL [	27	033	0	0	0	1	1	0	1
FS	CNTL \	28	034	0	0	0	1	1	1	0
GS	CNTL]	29	035	0	0	0	1	1	1	0
RS	CNTL ~	30	036	0	0	0	1	1	1	1
US	CNTL _	31	037	0	0	0	1	1	1	1
SP		32	040	0	0	1	0	0	0	0
!		33	041	0	0	1	0	0	0	0
‘‘		34	042	0	0	1	0	0	0	1
#		35	043	0	0	1	0	0	0	1
$		36	044	0	0	1	0	0	1	0
%		37	045	0	0	1	0	0	1	0
&		38	046	0	0	1	0	0	1	1
'		39	047	0	0	1	0	0	1	1
(		40	050	0	0	1	0	1	0	0
)		41	051	0	0	1	0	1	0	0
*		42	052	0	0	1	0	1	0	1
+		43	053	0	0	1	0	1	0	1
,		44	054	0	0	1	0	1	1	0
-		45	055	0	0	1	0	1	1	0
.		46	056	0	0	1	0	1	1	1
/		47	057	0	0	1	0	1	1	1
0		48	060	0	0	1	1	0	0	0
1		49	061	0	0	1	1	0	0	0
2		50	062	0	0	1	1	0	0	1
3		51	063	0	0	1	1	0	0	1
4		52	064	0	0	1	1	0	1	0
5		53	065	0	0	1	1	0	1	0
6		54	066	0	0	1	1	0	1	1
7		55	067	0	0	1	1	0	1	1
8		56	070	0	0	1	1	1	0	0
9		57	071	0	0	1	1	1	0	0
:		58	072	0	0	1	1	1	0	1
;		59	073	0	0	1	1	1	0	1
<		60	074	0	0	1	1	1	1	0
=		61	075	0	0	1	1	1	1	0
>		62	076	0	0	1	1	1	1	1
?		63	077	0	0	1	1	1	1	1

Appendix E
ɜ Control And Graphic Instructions

ɜl Group

ode On	~ '	[<STRING>] ASCII Characters <TERM> String Terminator
ɔnt	~ P	[<MBP>] Standard/Alternate Character Sets
ze	~ %	[<MBP>] Character Width/Height
ant	~ /	[<MBA>] Slant Angle
ıg Terminator	~ \	[<MBN>] Label String Terminator

ro Instructions Group

ıstruction Define	~ *	[<SBN> Macro Number [<PDS>]] Graphic Data z Terminate
ıstruction Invoke	{	<SBN> Assigned Macro Number
tic Macro Instruction	~ #	[<SBN>] Macro Instruction Number

er Advance Group (7221S Only)

:nable	~ (
)isable	~)
ɜ Full Page	~ +
ɜ Half Page	~ -

Abbreviations

DEC — Decimal
ASC — ASCII Encoded Digit
MBA — Multiple Byte Angle
MBN — Multiple Byte Number
MBP — Multiple Byte Pair of Numbers
PMB — Pair of Multiple Byte Numbers
PDS — Plot Data String
SBN — Single Byte Number
TERM — Label Terminate Character

Device

Graphic Instructions

) _

) W [<MBP> [<MBP>]]
Lower Left X, Y Upper Right X, Y

) S [<MBP>]
X max, Y max

) V [<SBN>]
Velocity cm/sec

) T [<SBN>]
Max Deviation

) [<SBN>]
Pen Number

) [<MBP> [{<MBP>}]]
Pen Up End Points Pen Down End Points

) [{<MBP>}]
Pen Down End Points

) [<PMB> [{<PMB>}]]
Pen Up End Point Pen Down End Points

) [{ <PMB>}]
Pen Down End Points

)
) [<MBN> [<MBA> [<MBA>]]]
Arc Radius Start Angle Stop Angle

) Q
) R [{<SBN>} <MBN>]
Pattern Definition Pattern Length

) [<MBA>]
Angle of Rotation

)

Labe

Label M

Label F

Label Si

Label Sl

Set Strir

Mac

Macro I

Macro I

Automa

Pap

Cutter E

Cutter D

Advanc

Advanc

ons

) [<ASC>] ; [<ASC>] ; [<ASC>]] :

Echo Terminate | Output Terminator | Output Terminator

{<ASC>}] :

Handshake String

; [<ASC>]] :

Immediate Response String

; [<ASC>]] :

Configuration Options

<pen number>

In Holder

Setup Group

Initialize ~

Set Graph Limits ~

Set Grid Size ~

Velocity Select ~

Arc Tolerance ~

Plot Group

Pen Select v

Move p

Draw q

Incremental Move r

Incremental Draw s

Arc Clockwise t

Arc Counterclockwise u

Fixed Dash Lines ~

Variable Dash Lines ~

Rotate w

Rotate at Last Angle x

I/O Control Group

Instruction	Syntax	Parameters
Plotter On	ESC . (	
Plotter Off	ESC .)	
Set Output Mode	ESC . M	[[<DEC>] Turnaround Delay (mS) ; [<ASC>] Output Trigger ;
Set Handshake Mode 1 (Per Output Mode)	ESC . H	[[<DEC>] Block Size (Bytes) ; [<ASC>] Handshake Enable ;
Set Handshake Mode 2	ESC . I	[[<DEC>] Block Size (Bytes) ; [<ASC>] Handshake Enable ;
Set Extended Output and Handshake Modes	ESC . N	[[<DEC>] Delay Between Output Characters (mS)
Set Plotter Configuration	ESC . @	[[<DEC>] Maximum Buffer Size (Bytes)
Abort Device Control Instructions	ESC . J	
Abort Graphic Instructions	ESC . K	

Output Group

Instruction	Syntax	PLOTTER RESPONSE
Output Identification	ESC . A	7221, <date code>, <ROM option> Model Firmware Plug-In
Output Buffer Size	ESC . L	<bytes> 0 to 1128 (0 - 3056 Option 001)
Output Buffer Space	ESC . B	<bytes> 0 to 1128 (0 - 3056 Option 001)
Output Status	ESC . F	<status> 16-Bit Word
Output Error	ESC . E	<type>, <byte>, <quantity> (See Appendix C)
Output Graphic Limits	ESC . G	<X min>, <Y min>, <X max>, <Y max> Lower Left Upper Right
Output Current Position	ESC . C	<X position>, <Y position>, <pen> Pen Coordinate Pen Coordinate Up/Down (0/1)
Output Digitized Point	ESC . D	<X position>, <Y position>, <pen state>, Point Coordinate Point Coordinate Up/Down
Output Extended Status	ESC . O	<status> 2-bit status word in the range of 0 to 3

EUROPE, NORTH AFRICA AND MIDDLE EAST

AUSTRIA
Hewlett-Packard Ges.m.b.H.
Handelska 52
P.O. Box 7
A-1205 **Vienna**
Tel: 351621 27
Cable: HEWPAK Vienna
Telex: 75923 hewpak a

BAHRAIN
Medical Only
Wael Pharmacy
P.O. Box 648
Bahrain
Tel: 54886, 56123
Telex: 8550 WAEL GJ
Cable: WAELPHARM

Analytical Only
Al Hamidiya Trading and Contracting
P.O. Box 20074
Manama
Tel: 259978, 259958
Telex: 8895 KALDIA GJ

BELGIUM
Hewlett-Packard Benelux S.A./N.V.
Avenue du Col-Vert, 1,
(Groenkraaglaan)
B-1170 **Brussels**
Tel: (02) 660 50 50
Cable: PALOBEN Brussels
Telex: 23-494 paloben bru

CYPRUS
Kypronics
19 Gregorios Xenopoulos Street
P.O. Box 1152
Nicosia
Tel: 45628/29
Cable: Kypronics Pandehis
Telex: 3018

CZECHOSLOVAKIA
Vyvojova a Provozni Zakladna
Vyzkumnych Ustavu v Bechovicich
CSSR-25097 **Bechovice u Prahy**
Tel: 89 93 41
Telex: 12133

Institute of Medical Bionics
Vyskumny Ustav Lekarskej Bioniky
Jedlova 6
CS-88346
Bratislava-Kramare
Tel: 4251
Telex: 93229

DDR
Entwicklungslabor der TU Dresden
Forschungsinstitut Meinsberg
DDR-7305
Waldheim/Meinsberg
Tel: 37 667
Telex: 518741

Export Contact AG Zuerich
Guenther Forgber
Schlegelstrasse 15
1040 **Berlin**
Tel: 42-74-12
Telex: 111889

DENMARK
Hewlett-Packard A/S
Datavej 52
DK-3460 **Birkerod**
Tel: (02) 81 66 40
Cable: HEWPACK AS
Telex: 37409 hpas dk

Hewlett Packard A/S
Navervej 1
DK-8600 **Silkeborg**
Tel: (06) 82 71 66
Telex: 37409 hpas dk
Cable: HEWPACK AS

EGYPT
I.E.A.
International Engineering Associates
24 Hussein Hegazi Street
Kasr-el-Aini
Cairo
Tel: 23 829
Telex: 93830
Cable: INTENGASSO

SAMITRO
Sami Amin Trading Office
18 Abdel Aziz Gawish
Abdine-Cairo
Tel: 24932
Cable: SAMITRO CAIRO

FINLAND
Hewlett-Packard OY
Nahkahousuntie 5
P.O. Box 6
SF 00211 **Helsinki** 21
Tel: (90) 6923031

FRANCE
Hewlett-Packard France
Avenue des Tropiques
Les Ulis
Boite Postale No. 6
91401 **Orsay-Cedex**
Tel: (1) 907 78 25
TWX: 600048F

Hewlett-Packard France
Chemin des Mouilles
B.P. 162
69130 **Ecully**
Tel: (78) 33 81 25,
TWX: 310617F

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Péricentre de la Cépière
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TWX: 510957F

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Le Ligoures
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13100 **Aix-en-Provence**
Tel: (42) 59 41 02

Hewlett-Packard France
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35100 **Rennes**
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TWX: 740912F

Hewlett-Packard France
18, rue du Canal de la Marne
67300 **Schiltigheim**
Tel: (88) 83 08 10
TWX: 890141F

Hewlett-Packard France
Immeuble péricentre
Rue van Gogh
59650 **Villeneuve D'Ascq**
Tel: (20) 91 41 25
TWX: 160124F

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Bureau de Vente
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Bâtiment Ampère
Rue de la Commune de Paris
B.P. 300
93153 **Le Blanc Mesnil Cédex**
Tel: (01) 931 88 50

Hewlett-Packard France
Av. du Pdt. Kennedy
33700 **Merignac**
Tel: (56) 97 22 69

Hewlett-Packard France
"France-Evry" immeuble Lorraine
Boulevard de France
91035 **Evry-Cedex**
Tel: 077 96 60

Hewlett-Packard France
60, Rue de Metz
57130 **Jouy aux Arches**
Tel: (87) 69 45 32

GERMAN FEDERAL REPUBLIC
Hewlett-Packard GmbH
Vertriebszentrale Frankfurt
Berner Strasse 117
Postfach 560 140
D-6000 **Frankfurt** 56
Tel: (0611) 50-04-1
Cable: HEWPACKSA Frankfurt
Telex: 04 13249 hpffm d

Hewlett-Packard GmbH
Technisches Büro Böblingen
Herrenberger Strasse 110
D-7030 **Böblingen**, Württemberg
Tel: (0703) 667-1
Cable: HEWPACK Böblingen
Telex: 07265739 bbn

Hewlett-Packard GmbH
Technisches Büro Dusseldorf
Emanuel-Leutze-Str 1 (Seestern)
D-4000 **Dusseldorf**
Tel: (0211) 59711
Telex: 085/86 533 hpdd d

Hewlett-Packard GmbH
Technisches Büro Hamburg
Wendenstrasse 23
D-2000 **Hamburg** 1
Tel: (040) 24 13 93
Cable: HEWPACKSA Hamburg
Telex: 21 63 032 hphh d

Hewlett-Packard GmbH
Technisches Buro Hannover
Am Grossmarkt 6
D-3000 **Hannover 91**
Tel: (0511) 46 60 01
Telex: 092 3259

Hewlett-Packard GmbH
Technisches Buro Nürnberg
Neumeyerstrasse 90
D-8500 **Nürnberg**
Tel: (0911) 58 30 83
Telex: 0623 860

Hewlett-Packard GmbH
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Eschenstrasse 5
D-8021 **Taufkirchen**
Tel: (089) 6117-1

Hewlett-Packard GmbH
Technisches Buro Berlin
Kaithstrasse 2-4
D-1000 **Berlin 30**
Tel: (030) 24 90 86
Telex: 018 3405 hpbln d

GREECE
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Athens 133
Tel: 32 30 303/32/37 731

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Athens 135
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No. 13, Fourteenth St.
Mir Emad Avenue
P.O. Box 41/2419
Tehran
Tel: 851082-5
Telex: 213405 hewp ir

IRELAND
Hewlett-Packard Ltd.
King Street Lane
Winnersh, Wokingham
Berks, RG11 5AR
GB-England
Tel: (0734) 78 47 74
Telex: 847178
Cable: Hewpie London

Hewlett-Packard Ltd.
2C Avonbeg Industrial Estate
Long Mile Road
Dublin 12, Eire
Tel: (01) 514322
Telex: 30439

Medical Only
Cardiac Services (Ireland) Ltd
Kilmore Road
Artane
Dublin 5, Eire
Tel: (01) 315820

Medical Only
Cardiac Services Co
95A Finaghy Rd. South
Belfast BT10 0BY
GB-Northern Ireland

ITALY
Hewlett-Packard Italiana S.p.A.
Via G. Di Vittorio, 9
20063 Cernusco
Sul Naviglio (MI)
Tel: (2) 903691
Telex: 311046 HEWPACKIT

Hewlett-Packard Italiana S.p.A.
Via Turazza, 14
35100 **Padova**
Tel: (49) 664888
Telex: 41612 HEWPACKI

Hewlett-Packard Italiana S.p.A.
Via G. Armellini 10
I-00143 **Roma**
Tel: (06) 54 69 61
Telex: 61514
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I-80131 **Napoli**
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I-40137 **Bologna**
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Amman
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Kuwait
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LUXEMBURG
Hewlett-Packard Benelux S.A./N.V.
Avenue du Col-Vert, 1
(Groenkraaglaan)
B-1170 **Brussels**
Tel: (02) 672 22 40
Cable: PALOBEN Brussels
Telex: 23 494

MOROCCO
Dolbeau
81 rue Karatchi
Casablanca
Tel: 3041 82
Telex: 23051/22822
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Casablanca
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Casablanca
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NETHERLANDS
Hewlett-Packard Benelux N.V.
Van Heuven Goedhartlaan 121
P.O. Box 667
NL-**Amstelveen** 1134
Tel: (020) 47 20 21

NORWAY
Hewlett-Packard Norge A/S
Osterdalen 18
P.O. Box 34
1345 **Osteraas**
Tel: (02) 1711 80
Telex: 16621 hpnas n

Hewlett-Packard Norge A/S
Nygaardsgaten 114
5000 **Bergen**

POLAND
Biuro Informacji Technicznej
Hewlett-Packard
Ul Stawki 2, 6P
00-950 **Warszawa**
Tel: 33.25.88/39 67 43
Telex: 81 24 53 hepa pl

UNIPAN
Biuro Obslugi Technicznej
01-447 Warszawa
ul **Newelska** 6
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Plac Komuny Paryskiej 6
90-007 **Lodz**
Tel: 334-41, 337-83
Telex: 886981

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Telectra-Empresa Técnica de Equipamentos Eléctricos S.a.r.l.
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Telex: 4439 NASSER
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Hewlett-Packard Reprezentanta
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Bucuresti
Tel: 15 80 23/13 88 85
Telex: 10440

I.I.R.U.C.
Intreprinderea Pentru Intretinerea
Si Repararea Utilajelor de Calcul
B-dul Prof. Dimitrie Pompei 6
Bucuresti-Sectorul 2
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Telex: 118

SAUDI ARABIA
Modern Electronic Establishment (Head Office)
P.O. Box 1228, Baghdadiah Street
Jeddah
Tel: 27 798
Telex: 40035
Cable: ELECTA JEDDAH

Modern Electronic Establishment (Branch)
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Riyadh
Tel: 62596-66232
Cable: RAOUFCO

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Al-Khobar
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SPAIN
Hewlett-Packard Española, S.A.
Calle Jerez 3
E-**Madrid** 16
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Telex: 23515 hpe

Hewlett-Packard Española S.A.
Colonia Mirasierra
Edificio Juban
% Costa Brava, 13
Madrid 34

Hewlett-Packard Española, S.A.
Milanesado 21-23
E-**Barcelona** 17
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Av Ramón y Cajal, 1
Edificio Sevilla, planta 9°
E-**Sevilla** 5
Tel: 64 44 54/58

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Edificio Albia II 7° B
E-**Bilbao** 1
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Hewlett-Packard Española S.A.
C/Ramon Gordillo 1 (Entlo.)
E-**Valencia**-10
Tel: 96-361.13.54/361.13.58

SWEDEN
Hewlett-Packard Sverige AB
Enighetsvägen 3, Fack
S-161 **Bromma** 20
Tel: (08) 730 05 50
Telex: 10721
Cable: MEASUREMENTS Stockholm

Hewlett-Packard Sverige AB
Frötallsgatan 30
S-421 32 **Västra Frölunda**
Tel: (031) 49 09 50
Telex: 10721 via Bromma office

SWITZERLAND
Hewlett-Packard (Schweiz) AG
Zürcherstrasse 20
P.O. Box 307
CH-8952 **Schlieren-Zurich**
Tel: (01) 7305240
Telex: 53933 hpag ch
Cable: HPAG CH

Hewlett-Packard (Schweiz) AG
Château Bloc 19
CH-1219 **Le Lignon-Geneva**
Tel: (022) 96 03 22
Telex: 27333 hpag ch
Cable: HEWPACKAG Geneva

SYRIA
General Electronic Inc.
Nuri Basha-Ahnaf Ebn Kays Street
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Damascus
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B.P. 2308
Damascus
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Sulelman Hilal El Mlawi
P.O. Box 2528
Mamoun Bitar Street, 56-58
Damascus Tel: 11 46 63

TUNISIA
Tunisie Electronique
31 Avenue de la Liberte
Tunis
Tel: 280 144

Corema
1 ter. Av. de Carthage
Tunis
Tel: 253 821
Telex: 12319 CABAM TN

TURKEY
TEKNIM Company Ltd
Riza Sah Pehlevi
Caddesi No. 7
Kavaklidere, **Ankara**
Tel: 275800
Telex: 42155

Teknim Com., Ltd.
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Ankara
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Analytical only
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Milli Mudafaa Cad 16/6
Kizilay
Ankara
Tel: 25 03 09 - 17 80 26
Telex: 42576 OZEK TR
Cable: OZYUREK ANKARA

UNITED ARAB EMIRATES
Emitac Ltd. (Head Office)
P.O. Box 1641
Sharjah
Tel: 354121/3
Telex: 8136

Emitac Ltd. (Branch Office)
P.O. Box 2711
Abu Dhabi
Tel: 331370/1

UNITED KINGDOM
Hewlett-Packard Ltd.
King Street Lane
Winnersh, Wokingham
Berks. RG11 5AR
Tel: (0734) 784774
Telex: 847178/9

Hewlett-Packard Ltd.
Trafalgar House
Navigation Road
Altrincham
Cheshire WA14 1NU
Tel: (061) 928 6422
Telex: 668068

Hewlett-Packard Ltd.
Lygon Court
Hereward Rise
Dudley Road
Halesowen,
West Midlands B62 8SD
Tel: (021) 550 9911
Telex: 339105

Hewlett-Packard Ltd.
Wedge House
799, London Road
Thornton Heath
Surrey CR4 6XL
Tel: (01) 6840103
Telex: 946825

Hewlett-Packard Ltd
10, Wesley St.
Castleford
Yorks. WF10 1AE
Tel: (0977) 550016
Telex: 557355

Hewlett Packard Ltd
1, Wallace Way
Hitchin
Hertfordshire, SG4 0SE
Tel: (0462) 31111
Telex: 82 59 81

USSR
Hewlett-Packard
Representative Office USSR
Pokrovsky Boulevard 4/17-kw 12
Moscow 101000
Tel: 294.20.24
Telex: 7825 hewpak su

YUGOSLAVIA
Iskra-Standard/Hewlett-Packard
Miklosiceva 38/VII
61000 **Ljubljana**
Tel: 31 58 79/32 16 74

SOCIALIST COUNTRIES NOT SHOWN PLEASE CONTACT:
Hewlett-Packard Ges.m.b.H
Handelska 52
P.O. Box 7
A-1205 **Vienna**, Austria
Tel: (0222) 35 16 21 to 27

MEDITERRANEAN AND MIDDLE EAST COUNTRIES NOT SHOWN PLEASE CONTACT:
Hewlett-Packard S.A.
Mediterranean and Middle East Operations
35, Kolokotroni Street
Platia Kefallariou
GR-Kifissia-**Athens**, Greece
Tel: 8080337/259/429

FOR OTHER AREAS NOT LISTED CONTACT
Hewlett-Packard S.A.
7, rue du Bois-du-Lan
P.O. Box
CH-1217 Meyrin 2 - **Geneva**
Switzerland
Tel: (022) 82 70 00

UNITED STATES

ALABAMA
P.O. Box 4207
8290 Whitesburg Dr.
Huntsville 35802
Tel: (205) 881-4591

8933 E. Roebuck Blvd.
Birmingham 35206
Tel: (205) 836-2203/2

ARIZONA
2336 E. Magnolia St.
Phoenix 85034
Tel: (602) 244-1361

2424 East Aragon Rd.
Tucson 85706
Tel: (602) 889-4661

***ARKANSAS**
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Tel: (501) 376-1844

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1430 East Orangethorpe Ave.
Fullerton 92631
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3939 Lankershim Boulevard
North Hollywood 91604
Tel: (213) 877-1282
TWX: 910-499-2671

5400 West Rosecrans Blvd.
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World Way Postal Center
Los Angeles 90009
Tel: (213) 776-7500
TWX: 910-325-6608

***Los Angeles**
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Santa Clara 95050
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646 W. North Market Blvd.
Sacramento 95834
Tel: (916) 929-7222

9606 Aero Drive
P.O. Box 23333
San Diego 92123
Tel: (714) 279-3200

***Tarzana**
Tel: (213) 705-3344

COLORADO
5600 DTC Parkway
Englewood 80110
Tel: (303) 771-3455

CONNECTICUT
12 Lunar Drive
New Haven 06525
Tel: (203) 389-6551
TWX: 710-465-2029

FLORIDA
P.O. Box 24210
2727 N.W. 62nd Street
Ft. Lauderdale 33309
Tel: (305) 973-2600

4428 Emerson Street
Unit 103
Jacksonville 32207
Tel: (904) 725-6333

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Orlando 32809
Tel: (305) 859-2900

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Medical Service Only
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Tel: (808) 955-4455

ILLINOIS
5201 Tollview Dr.
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Tel: (312) 255-9800
TWX: 910-687-2260

INDIANA
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Indianapolis 46250
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TWX: 810-260-1797

IOWA
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Iowa City 52240
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KENTUCKY
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Louisville 40218
Tel: (502) 456-1573

LOUISIANA
P.O. Box 1449
3229-39 Williams Boulevard
Kenner 70063
Tel: (504) 443-6201

MARYLAND
7121 Standard Drive
Parkway Industrial Center
Hanover 21076
Tel: (301) 796-7700
TWX: 710-862-1943

2 Choke Cherry Road
Rockville 20850
Tel: (301) 948-6370
TWX: 710-828-9684

MASSACHUSETTS
32 Hartwell Ave.
Lexington 02173
Tel: (617) 861-8960
TWX: 710-326-6904

MICHIGAN
23855 Research Drive
Farmington Hills 48024
Tel: (313) 476-6400

724 West Centre Ave.
Kalamazoo 49002
Tel: (606) 323-8362

MINNESOTA
2400 N. Prior Ave.
St. Paul 55113
Tel: (612) 636-0700

MISSISSIPPI
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Jackson 39206
Tel: (601) 982-9363

MISSOURI
11131 Colorado Ave.
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Tel: (816) 763-8000
TWX: 910-771-2087

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St. Louis 63141
Tel: (314) 878-0200

NEBRASKA
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Omaha 68106
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Paramus 07652
Tel: (201) 265-5000
TWX: 710-990-4951

Crystal Brook Professional Building, Route 35
Eatontown 07724
Tel: (201) 542-1384

NEW MEXICO
P.O. Box 11634
Station E
11300 Lomas Blvd., N.E.
Albuquerque 87123
Tel: (505) 292-1330
TWX: 910-989-1185

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Las Cruces 88001
Tel: (505) 526-2484
TWX: 910-9983-0550

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Tel: (716) 223-9950
TWX: 510-253-0092

No.1 Pennsylvania Plaza
55th floor
34th street & 8th Avenue
New York 10001
Tel: (212) 971-0800

5858 East Molloy Road
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Tel: (315) 455-2486

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Tel: (516) 921-0300

NORTH CAROLINA
5605 Roanne Way
Greensboro 27405
Tel: (919) 852-1800

OHIO
Medical/Computer Only
Bldg. 300
1313 E. Kemper Rd.
Cincinnati 45426
Tel: (513) 671-7400

16500 Sprague Road
Cleveland 44130
Tel: (216) 243-7300
TWX: 810-423-9430

330 Progress Rd.
Dayton 45449
Tel: (513) 859-8202

1041 Kingsmill Parkway
Columbus 43229
Tel: (614) 436-1041

OKLAHOMA
P.O. Box 32008
6301 N. Meridan Avenue
Oklahoma City 73112
Tel: (405) 721-0200

9920 E. 42nd Street
Suite 121
Tulsa 74145

OREGON
17890 SW Lower Boones Ferry road
Tualatin 97062
Tel: (503) 620-3350

PENNSYLVANIA
111 Zeta Drive
Pittsburgh 15238
Tel: (412) 782-0400

1021 8th Avenue
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